MEMORANDUM REPORT

ON SURFACE WATER AVAILABILITY IN THE

LAKE ISTOKPOGA-INDIAN PRAIRIE AREA

RESOURCE PLANNING DEPARTMENT

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INTRODUCTION

The Istokpoga - Indian Prairie basin occupies the northeast corner of Glades County and the southeast corner of Highlands County. It is bordered on the north by Lake Istokpoga, on the south by Lake Okeechobee. The Kissimmee River lies on the east, while the Highlands Ridge borders the west. It is approximately 416 square miles in area. Of this total, approximately 55 sq. mi. lies between the interceptor levees (L-59, 60,and 61) and Lake Okeechobee.

Roughly 70% of the land within the basin is undeveloped. Of the 30% which is developed, approximately 26% lies in improved pasture; the remaining 4% is citrus and, to a lesser extent, truck crops.

Four canals (C-40, C-41, C-39A and C-41A) traverse the basin from Lake Istokpoga to Lake Okeechobee. The canals are the main water control system. They remove excess water from the basin during the wet season to Lake Okeechobee and are the primary conveyors of supplemental water from Lake Istokpoga during the dry season. Only the Istokpoga Marsh Drainage District and an area around Istokpoga Canal obtain supplemental water directly from the lake. This latter area is approximately 16 sq. mi. in extent (not included in the 416 sq. mi. total, above).

The lower portion of the study area does not discharge into the canal system, but discharges directly into Lake Okeechobee by way of Pumping Stations 127, 129 and 131. Irrigation supply for this area is derived from Lake Okeechobee directly and, in a limited area, from the canal system by way of the interceptor levee canals.

The map of Figure 1 shows the drainage basins of the primary canals, the drainage areas of Pumping Stations 127, 129 and 131, the boundaries of the Istokpoga Marsh district, and the area irrigated from the Istokpoga Canal.

The number of agricultural water users is presently very small but represents a large portion of the total potentially irrigatable areas. Under the existing permit system these users are restricted to a maximum of 7.5 inches of water per month. However, this is presently the only constraint on water use. This constraint is not related to hydrologic conditions of water availability in the basin.

The main purpose of this study is to identify, quantify and evaluate the hydrologic constraints operative in the study area which can have a bearing on surface water allocations for agricultural irrigation use.

A corollary purpose of this study is to establish, in accordance with the statutory requirements, minimum levels for Lake Istokpoga, minimum flows to Lake Okeechobee to be maintained from the study area, and minimum flows into Lake Istokpoga. These requirements, once established, act, in turn, as three of the major hydrologic constraints on the amount of surface water generated within the study area which is available for beneficial use and allocation.

Recommendations will be made concerning:

1. Guidelines for use in the evaluation of new surface water permit applications;
2. Treatment of valid surface water use permits in existence prior to March 1, 1974;
3. Guidelines for water supply operations of the District system in the study area;
4. Future courses of action, and continuing studies and data collection.

GENERAL

The volume of surface water which is potentially available for allocation for beneficial use in the Indian Prairie Area consists of three components: (a) run-off generated over the basin south of Lake Istokpoga and which is conveyed to Lake Okeechobee by Canals 40, 41, and 41A; (b) water in canal storage which represents that fraction of groundwater in-seepage which is not discharged at the downstream spillways plus any irrigation return flow which similarly is not discharged from the basin; and (c) stored water in Lake Istokpoga which can be conveyed into the basin south of Istokpoga by means of the same canals.

The first component is transient water and although it can potentially be made available for beneficial irrigation use by the development of off-line storage by individual users, it is at present only marginally useful, if at all, for meeting supplemental water requirements.

The second component undoubtedly plays some part in meeting supplemental water requirements in the basin. It can probably be approximately quantified, but not from presently available data. No attempt has been made in this study to quantify it and consequently it is not considered at this time as part of the allocable surface water.

The third component furnishes by far the greatest portion of the basin's supplemental water supply. Lake Istokpoga serves as the study area's water supply reservoir.

The total amount of water potentially available for allocation, therefore, is considered to be surplus run-off water and some portion of the water stored in Lake Istokpoga. The canal storage (in-seepage) component is available for use but because it is unquantifiable at this time, it is

not included in the potentially allocable volumes. From the user's standpoint, it provides a "cushion" of some unknown value.

All of the excess run-off is potentially available for allocation and use. However, minimum flow requirements to Lake Okeechobee must be met. These requirements come "off the top" and thus the volume of excess run-off water available for allocation is the potential volume minus the minimum flow volume.

In further connection with the minimum flow requirement, only the excess run-off component is used to meet this requirement. Under natural conditions (prior to any canal construction) Lake Istokpoga only rarely, if at all, contributed flows to Lake Okeechobee. It is not considered reasonable to impose the minimum flow requirement on the limited stored water resource of Lake Istokpoga.

Theoretically, all the stored water in Lake Istokpoga down to the limits imposed by the configuration of S-68 and the adjacent lake bottom is potentially available to meet supplemental water requirements. The statute requires only the establishment of minimum lake levels. On the above basis, then, the minimum level for Lake Istokpoga could be established in conformity with the physical constraints of S-68 and the lake bottom. However, the statute also instructs the water management districts to consider such other factors as fish, wildlife and recreation. Recreational boating use of the lake is an important consideration and together with esthetic considerations, must be taken into account in setting minimum levels.

The water actually available for allocation to the basin south of Lake Istokpoga, then, is constrained by whatever minimum lake levels are established. In addition, it is considered that not all of the allocable lake storage be made available for use in the basin south of the lake;

that is, that some portion be reserved for contingent uses not now in existence and not foreseen at this time. Consequently, it is believed prudent at this time to reserve as unallocated 15% of the total allocable lake storage volume for: (a) potential users around the lake, and (b) possible permissible allocations from tributary streams; i.e., Arbuckle Creek, Josephine Creek.

EXCESS RUN-OFF COMPONENT

This component is termed "basin yield." The computation of monthly basin yield is facilitated by dividing the basin into three parts, determining the yield of each area, then summing. The major area of yield consists of that region north of the interceptor canals whose runoff passes through S-71, S-72, and S-84. The second area consists of a strip one mile wide north of the interceptor canals whose runoff does not pass through S-71, S-72, or S-84; and the third area of yield passes its water through Pumping Stations S-127, S-129, and S-131.

Yield in the first area was calculated by summing daily discharges through S-71, S-72, and S-84. From this sum, daily discharges through S-68 were removed. The period of record used was from January, 1964 through December, 1973.

Yield in the second area was estimated, since surplus runoff generated in this area discharges below the lower control structures. This yield was estimated, by proportioning areas, to be about 5 percent of the yield produced from the first area.

Monthly values of discharge through S-127, S-129, and S-131 were used for yield in the area south of the interceptor canals. Five years of record was available for this area. Averaged monthly values were used to supply missing data.

Monthly yields in each of the three areas were summed to give the total basin yield (Table 1). Monthly basin yields were then arrayed in a frequency distribution (Figures 2a, 2b, 2c, and 2d).

The question arises as to what yield volume should be considered that which is allocable. It should be a volume on which the user can place some reasonable reliance. Certainly neither the maximum nor minimum values meet

this criterion. Use of the averages can result also in an unrealistic picture, because of the short record; see for example the March average which is obviously unbalanced because of the single large value for 1970.

Since it is a matter of probability, the two-year frequency value for each month was selected (see Figures 2a, b, c and d) as representing the potential allocable volume for the excess run-off component of available water supply.

An arbitrary judgment was made that the low flow on a five year recurrence interval would be established as the minimum flow to be maintained out of the basin into Lake Okeechobee.

Table 2 lists the monthly values for total basin yield, flow maintenance requirement, and adjusted basin yield (or allocable volume), in acre feet.

None of these values have been adjusted to include irrigation withdrawals which were made during the record period. The impact of such withdrawals during the wet season is negligible. During the dry season the operating policy of generally maintaining "irrigation stage" by supply from Lake Istokpoga makes it probable that the impact during those months is also negligible; i.e., supplemental water supply during the irrigation season is largely derived from lake storage and therefore irrigation withdrawals are not a deduction from the basin yield component.

LAKE ISTOKPOGA STORAGE COMPONENT

This portion of the water supply availability study necessarily starts with the establishment of a minimum stage for Lake Istokpoga. The interpretation taken for "minimum stage" in this instance is that it is that lake level below which no further releases would be made for irrigation water use in the basin south of the lake and in the areas served directly from the lake.

Based on staff knowledge of recreational navigation access problems in the lake, and lake residents' views of desirable lake stages as expressed at public meetings and in correspondence to the District, a judgment determination was made setting minimum lake stage at 37.0 ft.msl. For comparison, the Project regulation schedule calls for a minimum flood storage pool stage of 37.5 ft. msl. on June 1.

The first full year of project regulation was 1963. From 1963 through 1974 stage was at or slightly below 37.0 ft. msl. in June and July, 1967 and from mid-May to date, 1974. From May-August, 1971, subsequent to the severe 1970-71 drought, stage was below 37.0 ft. msl. with a low stage approximating 36.1 ft. msl. Accordingly, from several standpoints a stage of 37.0 ft. msl. appears to be a reasonable minimum. If anything, this minimum favors agricultural water supply values over recreational navigation and esthetic values.

Two approaches are possible: (a) to establish monthly minimum stage values; and (b) to establish only a single absolute minimum stage. Each approach has certain disadvantages. In the latter case it would be theoretically possible to draw the lake stage down for irrigation water supply to the minimum stage of 37.0 ft.msl. in February or March. Under this circumstance natural dry season recession would produce stages well below 37.0 ft. in

missing data was estimated using averages of existing data.

The minimum monthly stages established in this fashion are keyed directly to average monthly "natural" depletion rates expressed as a percentage of seasonal natural depletion. The stage recession (depletion) calculated in this fashion is conservative in that tributary inflow is not considered. It will be noted, also, that the greatest permissible drawdowns for irrigation water supply occur during the months of April and May, normally the months of greatest supplemental water demand.

In order to arrive at both minimum monthly stages for the wet season (June through October) and the total volume of water potentially available for allocation from Lake Istokpoga storage a theoretical, or "fictitious", stage computation was made. This fictitious stage is the stage to which the lake would rise were there no discharges. It was calculated by adding monthly discharges to actual lake stage.

Table 4 shows Lake Istokpoga monthly discharges in acre-feet. This is the sum of S-68 discharges, Istokpoga Canal discharges (averaged for missing data) and Istokpoga Marsh Drainage District discharge (estimated).

Accumulated monthly discharges for each season are shown in Table 5. The equivalent lake storage stage for this monthly accumulated discharge was added to actual month-end lake stage (Table 6) to compute the fictitious stage (Table 7). From the monthly fictitious stages, monthly changes in fictitious stage were found using May 31 actual stage as the starting base (Table 8). The changes in stage were then arrayed in a frequency distribution (Figure 3).

The frequency distribution of monthly, and accumulated, stage accretions during the wet season shows that, theoretically, the October stage of 39.5 ft. msl. can be achieved during the 1 in 20 year frequency rainfall deficient period provided no regulatory or irrigation discharges are made during the period. From this distribution wet season minimum monthly stages were

derived using the accretions for the 20-year deficiency occurrence. These, together with the suggested preliminary dry season minimums, are plotted with the Project regulation schedule on Figure 4.

As noted above, the "fictitious" stage was also used to calculate the total volume of water which arrives in Lake Istokpoga and can be considered potentially available to meet agricultural irrigation requirements in the basin south of the lake. The once-in-two-year frequency actual end-of-May lake stage is 37.6 ft.msl. (see data listed for May 31 stage in Table 8). The frequency array of Figure 3 shows the June 1 to November 1 once-in-two-year frequency stage change to be 5.4 feet. Accordingly, the two-year frequency November 1 fictitious stage is 43.0 ft. msl.

The total water potentially available, on a once-in-two-year frequency, during the wet season is the difference between the fictitious November 1 stage of 43.0 ft. and the regulated stage of 39.5 ft. Using the Corps of Engineers stage-storage curve for Lake Istokpoga, this volume is 108,500 acre-feet. Expressed in another fashion, and in practical terms, this is the total volume of water which could potentially be drawn off from the lake during the wet season and diverted into off-line reservoirs in the basin south of the lake.

In the event water arriving in the lake is used in this fashion, the minimum monthly wet season lake stages have some significance. They then represent wet season lake stages below which diversions to off-line reservoirs would not be permitted. If diversions were permitted to continue at stages below these minimums, the District and other irrigation users could not be reasonably assured that a November 1 stage of 39.5 ft. msl. would be achieved.

On the other hand, if no off-line reservoir storage is created in the basin south of the lake, the minimum monthly wet season stages have no

practical application at this time. The reason for this is that releases from the lake for "as needed" irrigation water supply during this period are practically non-existent and thus insignificant.

The total volume of water arriving in the lake and potentially available for irrigation water supply during the dry season can be similarly calculated using the fictitious stage. The average end of May fictitious lake stage is 41.5 ft.msl. (see Table 7); this also approximates the once-in-two-year frequency fictitious stage of 41.6 ft. msl. The water potentially available during the dry season, therefore, is that between 41.5 ft. msl. and the established May minimum of 37.0 ft. msl. The stage-storage curve gives a volume of 132,500 acre-feet between these stages. This method indirectly accounts for inflow to the lake, evaporation losses and rainfall on the lake.

An approximate verification of this value is obtained by examining the releases actually made from the lake (whether regulatory or for water supply) during the period of record. Table 4 lists the lake releases. The average dry season release volume approximates 123,500 acre feet.

On page 5 of this report it was determined that 15% of the total volume of water which arrives in Lake Istokpoga, and which is potentially available for irrigation supply south of the lake, should be reserved for other contingent purposes. Accordingly, the seasonal volumes of water arriving in the lake which are allocable to agricultural users in the basin to the south are 85% of the values given above, or:

Wet season - June through October - 92,200 A.F.

Dry season - November through May - 112,600 A.F.

As noted on page 1, the entire study area contains 416 sq. mi. All of this area is involved in, and contributes to, the basin yield component of allocable water. In considering the lake storage component the 55 sq. mi.

area downstream of the interceptor levees must be subtracted from, and the 16 sq. mi. area adjacent to the Istokpoga Canal must be added to, the 416 sq. mi. figure to arrive at the total area which receives supplemental water supply, or can potentially receive such supply, from Lake Istokpoga. This area, then is 377 sq. mi.

On this basis, the following tabulation gives an approximate indication of water availability in acre-feet and in inches/acre for the area which presently, or is potentially, irrigatable with water supplied from the District system.

	From lake		From basin		Total	
	A.F.	In/A	A.F.	In/A	A.F.	In/A
Wet Season	92,000	4.6	55,900	2.6	148,100	7.2
Dry Season	112,600	5.6	12,990	0.6	125,590	6.2
Annual	204,800	10.2	68,890	3.2	273,690	13.4

Final values to be used for permit application evaluation are presented in Table 14 and are discussed under the heading "Surface Water Allocations."

It is recognized that establishing the tributary minimum flows in this fashion in effect reserves upstream water for future downstream users. However, at this time it appears that the ultimate demand for water genererated in this basin will be significantly greater in the area below Istokpoga. Circumstances can nevertheless change and the equity of this type of distribution of available water must be periodically evaluated.

PRESENT IRRIGATION USE

Irrigation withdrawals from Lake Istokpoga are accomplished by two means. These are: (a) withdrawals directly from the lake to Istokpoga Marsh and to the area adjacent to Istokpoga Canal, and (b) withdrawals from the canal system fed by the lake via S-68. Withdrawals from the canals were calculated on a daily basis as the difference between that water which passed through S-68 but did not leave through the lower structures (S-71, S-72, and S-84). These daily amounts were summed to determine monthly values. From these sums and the total irrigated area, the amount of water applied per acre was computed. This monthly amount applied per acre was used as the basis for estimating withdrawals directly from the Lake to Istokpoga Marsh.

Table 13 gives the total estimated withdrawals. It can be seen that the average dry season irrigation use has been approximately 36,000 acre feet. This amount is one half of lake storage between stages 39.5 and 37.0 feet. However, this figure does not include evaporation, inflow, precipitation or seepage.

The area presently being irrigated is estimated at 55,000 acres. The average dry season irrigation use of about 36,000 acre feet is, of course, for the period of record during which irrigated acreage has obviously increased. A general idea of the magnitude of supplemental water use in the basin south of Lake Istokpoga can be obtained by using the present estimated irrigated acreage and the calculated average irrigation use over the period of record. Using these values an average seasonal supplemental water application figure of 7.9 inches per acre is derived. This somewhat low use rate is probably accounted for by the high proportion of pasture land in the total irrigated acreage.

Referring to the tabulation on page 12, it will be noted that the water available in the dry season alone is not sufficient to meet the estimated level of demand with full basin development. To sustain a full level of development or more intensive development, and to provide for rainfall deficient periods, it appears that off-line storage of wet season surpluses will be required or groundwater sources must be developed. Groundwater use in the basin is presently limited to certain citrus groves in the northerly portion of the study area which do not have ready access to surface water sources.

Until larger private capital investments in facilities for making water available "on the land" are made, it appears that agricultural development will largely be limited to improved pasture in areas having comparatively easy and inexpensive access to the primary canal system.

Under present conditions of land development and irrigation practice, demands can ordinarily be met. But critical conditions can arise in rainfall deficient dry seasons, such as the 1973-74 season. Lake Istokpoga storage just barely met minimum irrigation requirements as a result of a November, 1973 through April, 1974 rainfall deficiency of 7 inches. Lake Istokpoga dry season storage alone will obviously be incapable of meeting expanded needs during future periods of even moderate stress.

SURFACE WATER ALLOCATIONS

The basic premise is that, initially at least, the surface water which has been determined to be available for allocation to the area south of Lake Istokpoga be allocated on a unit land area basis. The tabulation on page 12 of this report is such a unit area allocation.

The second premise, based on the data compiled and analyzed in the preparation of this report, is that surface water allocations to users in this basin should be based on hydrologic considerations. After taking into consideration the mandated hydrologic constraints of:

1. Maintenance of minimum flows to Lake Okeechobee;
2. Maintenance of minimum flows in Arbuckle and Josephine Creeks; and
3. Minimum Lake Istokpoga stages;

it is quite apparent that the basin does not generate abundant water surpluses.

The surface water available to the basin can be appropriated by users through two means:

1. On an "as-needed" basis either directly from the lake or from the District canal system; or
2. By impoundment either by diversion from the lake or canal system, or by capture of runoff before it enters the canal system.

It is possible to issue allocation permits on a monthly, seasonal, or annual basis; or some combination of these. The monthly, seasonal, and annual values presented herein are to be used only as guides in the evaluation of new applications or in the consideration of existing water use permits. They represent maximum allocable volumes only; i.e., if an applicant requests a lesser amount, that lesser amount will be allocated provided all other required criteria are met.

An applicant whose use will be on an "as-needed" basis should be issued an allocation only for an irrigation season withdrawal and an annual total. The maximum permissible allocations for those applicants who draw directly from Lake Istokpoga (except the Istokpoga Marsh D.D.) will consist only of the lake storage component. Except for the 55 sq.mi. area below the interceptor levees, the maximum permissible allocations for all others in the basin will consist of both the lake storage component and the basin yield component. The Istokpoga Marsh D.D. is included in this latter group since runoff from that area contributes to basin yield. Water allocations for the area below the interceptor levees will be treated in another report.

Applicants whose use involves impoundment should be issued allocations on a monthly basis. The basis for this is the assumption that this type of use will involve provision of facilities capable of diverting and impounding large volumes of water. Without a monthly limitation the potential exists for drawing lake and/or canal stages below established minimums to the detriment of other users. As above, the distinction is to be made in maximum permissible allocation volumes between direct lake withdrawals and withdrawals from the canal system.

It is considered important to maintain as much flow of surplus water into Lake Okeechobee as possible consistent with reasonable water use within the basins in which the flow is generated. This consideration applies in this study area. Consequently, impoundment permittees should not be allowed to divert or impound more than the maximum allowable monthly volumes unless concurrent regulatory discharges from Lake Okeechobee are being made. This constraint applies both to regulatory discharges from Lake Istokpoga and to excess basin runoff.

Table 14 lists the maximum permissible allocations for the two types of use and the two withdrawal categories identified above. The table lists total allocable volume for the basin and the unit land area maximum, based on a 416 sq.mi. service area for the basin yield component and a 377 sq.mi. service area for the lake storage component. The monthly volumes for the lake storage component have been distributed in five equal amounts for the wet season. The distribution of the lake storage component for the dry season is in accordance with the monthly percentages listed in Table 3.

The basin yield (or run-off excess) component incorporated in the values listed in Table 14 assumes a uniform yield over the entire 416 sq.mi. drainage basin. It may become necessary at a later date to refine these values on a canal drainage basin basis; but only when it becomes apparent that off-line storage will be created to make maximum use of this component.

MINIMUM STAGES AND MINIMUM FLOWS

1. A comparison of the suggested preliminary monthly minimum lake stages presented on Figure 4 with the actual month-end stages listed in Table 6 indicates the following:

Month	Actual Month-end Stage Lower than Suggested Min.	Average Stage Deficiency, ft.
November	3 of 10 months	0.57
December	2 " " "	0.70
January	1 " " "	0.72
February	1 " " "	0.42
March	1 " " "	0.75
April	1 " " "	0.50
May	2 " " "	0.38
June	2 " " "	0.32
July	2 " " "	0.45
August	1 " " "	1.16
September	3 " " "	0.25
October	6 " " "	0.48

The months with only 1 or 2 stage deficiency occurrences (December through August) experienced the one deficiency during the 1970-71 drought; in other words this deficiency represents a single severe occurrence. This indicates that the minimum monthly Lake Istokpoga stages initially suggested for these months theoretically are generally appropriate. The above tabulation also indicates that the suggested preliminary minimum stages for the months of September through November require some adjustment to conform more closely with actual experience.

A comparison of present irrigation demand levels reveals that some further adjustment is desirable in order to minimize the objections noted on page 8 concerning termination of irrigation supply flows while apparently ample storage still remains in the lake.

A more or less arbitrary judgment was applied in making these adjustments. The following tabulation lists the recommended minimum monthly stages for Lake Istokpoga. These represent those stages below which, when reached at any time during the month, no further water supply releases will be made at S-68 and users withdrawing directly from the lake will be notified to terminate such withdrawals.

MONTH	RECOMMENDED MIN.STAGE
November	38.8
December	38.5
January	38.4
February	38.4
March	38.3
April	37.5
May	37.0
June	37.0
July	37.3
August	38.0
September	38.3
October	39.0

A visual representation of the storage represented by these minimum stages in comparison with present average irrigation demand levels plus P-ET is presented in Figure 7.

The recommended minimum lake stage schedule is a step-type schedule, and is shown on Figure 4. It is expected that some flexibility will be possible, and applied, in actual operations; for example near the end of the month of

March where there is a difference of 0.8 ft. between the March and April minimums. The allowable margin of flexibility is to be established, administratively, by the Department of Field Services. The stages listed above, however, will be those officially adopted and published.

In adopting and publishing the minimum lake stage schedule the District must reserve the right to periodically depart from that schedule for environmental/water quality reasons.

2. Having established a schedule of minimum monthly stages below which no irrigation releases will be made at S-68 and no irrigation withdrawals directly from the lake will be permitted, it will be necessary to establish minimum canal stages in the several reaches of Canals 40, 41, 41A and 39A. Without establishing such minimum stages, when irrigation supply releases at S-68 are terminated the tendency will be for irrigators to draw on canal storage to the potential detriment of the canal section.

The minimum canal stages are to be determined by the Department of Field Services. These minimums are to be officially established and published, and should be made conditions of the water use permits issued by the District for withdrawals from the canal system.

It is recommended that the termination of releases at S-68 when minimum lake stage is reached be applicable only to irrigation water supply releases. Releases required to maintain minimum canal stages (replacement of evaporation losses, and seepage losses - if any) are to be made regardless of Lake Istokpoga stage. The maintenance of minimum canal stages for the purposes of protecting the District facility takes precedence, therefore, over the maintenance of minimum lake stages.

3. Monthly minimum flow maintenance requirements to Lake Okeechobee are listed in Table 2. At this point it appears to make little difference at

which of six different discharge points (S-71, 72, 84, 127, 129, or 131) the minimum flows are delivered to the Lake. Accordingly, the sum of the discharges at all six locations will be used to determine if minimum flow maintenance requirements are being met. However, further studies in the Lake may indicate the desirability of specifying amounts by location.

The Department of Field Services will have the responsibility for ensuring that minimum flow requirements are met, applying whatever accounting procedures are suitable.

Lake Istokpoga water is not to be deliberately used to maintain minimum flows to Lake Okeechobee. Consequently, when minimum Lake Istokpoga stage is reached and only minimum stages in the canal system are being maintained, the requirement for minimum flows to Lake Okeechobee is terminated. Both the maintenance of minimum stages in Lake Istokpoga and the maintenance of minimum canal stages takes precedence over flow maintenance requirements to Lake Okeechobee.

It is recognized that there will be some difficulty during certain periods in determining if minimum flows to Lake Okeechobee are being maintained by Lake Istokpoga water, basin base flow, or a combination of both. This does not appear to be too important a consideration and for present purposes can be ignored.

Monthly minimum flow maintenance values from the basin to Lake Okeechobee are to be officially adopted and published.

4. Flows in Arbuckle and Josephine Creeks are unregulated by the District. Therefore, the minimum flow values listed in Tables 11 and 12 have no operational implications. The establishment of these values is solely for the purpose of providing the Regulation Division an upper limit for the maximum permissible future water use diversions in each of these watersheds.

These minimum monthly flow values are to be officially adopted and published by the District.

SHALLOW GROUNDWATER USE

For all practical purposes nothing is known concerning the extent, depth and hydraulic characteristics of the shallow groundwater systems (water table aquifers) in the basin south of Lake Istokpoga. The important consideration is the degree of hydraulic connection of these aquifers with the surface water system; that is, the extent to which shallow groundwater extractions affect surface water availability from the primary canals. Accordingly, a highly arbitrary determination of criteria must be made on an interim basis until more knowledge is obtained in this regard.

It will prima facie be assumed that all non-exempt groundwater extraction systems:

(a) which are located within one mile of the centerline of any of the primary canals;

(b) which are located within one mile of the centerline of any canal connecting with the primary system and whose depth below ground-level is in excess of 15 feet; or

(c) whose zero drawdown contour falls within these one mile limits,

are the equivalent of a system which withdraws water directly from the primary canal network and will be treated in all respects in the same fashion. The applicant will, of course, be given the opportunity to demonstrate that his proposed extraction does not influence surface water availability. Failing such demonstration to the satisfaction of the District, the prima facie assumption initially made will hold.

The above equivalency of groundwater extraction to surface water extraction applies only to the basin yield component of total available, and allocable, surface water.

WATER SUPPLY AND WATER USE ACCOUNTING

Chapter 373.042 provides that the Governing Board shall establish minimum water levels and states that "the minimum water level shall be --- the level of surface water at which further withdrawals would be significantly harmful to the water resources of the area." This section of the statute further states that "when appropriate, minimum --- levels may be calculated to reflect seasonal variations." Finally, this section states that "the governing board shall also consider --- the protection of nonconsumptive uses in the establishment of minimum --- levels."

The approach recommended herein concerning minimum Lake Istokpoga stages follows the above, admittedly discretionary, language. That is, by recommending the establishment of monthly minimum stages full account is taken of "seasonal variations" and due consideration is given to "protection of nonconsumptive uses." Neither of these factors is given appropriate weight if only a single absolute minimum stage is established. Furthermore, the data presented herein indicates that this approach will not be unreasonably restrictive of present consumptive beneficial uses in the basin.

The provisions of the statute in another area, Chapter 373.175 dealing with the declaration of water shortage and emergency orders, raise an issue of some potential concern in terms of possible conflict with the provision for establishing minimum stages. In practical terms the situation is this: when Lake Istokpoga stage is above the monthly minimum full water allocations can be met, but when stage recedes to the minimum, withdrawals are terminated; this is a situation which can develop overnight.

The potential conflict arises from the fact that the statute implies that, except under unusual circumstances, reasonable notice be given that a

water shortage exists. The situation described in the previous paragraph does not, presumably, meet the requirement of reasonable notice to permitted water users of an impending water shortage. (See also here Ch. 16CA-2.12(1), Ch. 16CA-2.13(1) and (2) of District Rules and Regulations).

This indicates that it will be necessary to establish a simplified continuous accounting procedure wherein water supply is related to and compared with estimated (or actual) water use. A plotting of Lake Istokpoga storage above elevation 37.0 ft.msl. versus reverse accumulated (remaining) demand from November 1 through May 31 will provide such an accounting method. This is a set of graphs similar to that prepared for Lake Okeechobee and described in the recent issue of "In Depth Report."

This set of supply-demand graphs should be maintained by the Regulation Division, and can be developed in that Division. It is recommended that the average monthly estimated irrigation withdrawals, November-May, presented in this memorandum report, together with the monthly P-ET values, be used initially to develop the "remaining demand" curve. To plot available supply, daily lake stages (S-68) are to be furnished by the Department of Field Services, and the Resource Planning Department will furnish stage-storage curves for conversion of lake stage to stored water volume above elevation 37.0 ft.msl.

Figure 7 displays a set of supply-demand curves in which average period of record month-end stage is used to determine available storage, as an example.

By maintaining a continuous plotting of available storage during the irrigation season and relating this to both estimated remaining demand and monthly minimum stages (storage levels) the Regulation Division will be in a position to notify permittees of impending water shortages and the estimated size of the deficiency. It will also be possible to develop a procedure whereby water use can be reduced on a percentage basis when minimum monthly stages are approached.

PERMIT CLASSIFICATION

Chapter 373.246 states that the "Governing Board shall adopt a reasonable system of permit classification according to source of water supply, method of extraction or diversion, use of water, or a combination thereof." The Rules and Regulations adopted by the District pursuant to the statute state in Chapter 16CA-2.12(2) that "for the purpose of the water shortage plan only, each permit shall be classified according to source and use." (underscoring supplied).

The Rules and Regulations specify that each permit be given one or both of the following source classifications: groundwater, and surface water. They further specify that each permit be given one or more of the following classifications as to use: domestic, essential services, public supply, livestock, agricultural, industrial, mining, power and recreational.

A water shortage condition is normally considered as being applicable to a geographical area. However, a water shortage can occur with respect to a particular source as well. Consequently, it is entirely possible that within any geographical area there may be a shortage of water in one water source located within that area and no shortage in another water source. The classic example is a water shortage in a surface water/water table aquifer system separated by an aquiclude from a deep aquifer system in which there is ample water. The controlling factor is the degree of hydraulic interconnection between the several elements of the surface water system, the surface water system and the groundwater table aquifers, and the shallow aquifers and the deeper aquifers.

Therefore, a declaration of water shortage must, in most cases, describe not only the geographical area in which the shortage exists but the source which is deficient. The classification of permits as to "source" must also

take this into account. This means that, generally speaking, a simple source classification distinction between "ground" and "surface" sources is insufficient. Adequate qualifiers must be applied to the two basic source descriptions to clearly and sufficiently define the separable sources which may possibly be treated differently under a water shortage declaration.

For the purposes of permit classification, the geographical area to which the system recommended herein will apply consists of:

1. All land areas which presently, or will in the future, receive their water supply directly from Lake Istokpoga;
2. All of the lands which lie within the designated drainage basins of Canals 40, 41, 41A and 39A, as generally shown on the map of Figure 1; and
3. Those lands which presently receive their water supply from the borrow canals of interceptor levees L-59, 60 and 61.

This specifically excludes those lands located between the interceptor levees and Lake Okeechobee, except for those parcels which by separate agreement have been permitted to irrigate from water in the interceptor borrow canals. As noted on page 16, this 55 sq. mi. area will be covered in a separate report.

The following will be considered as a single source when application of water shortage measures becomes necessary:

1. Lake Istokpoga.
2. Canals 40, 41, 41A and 39A.
3. The borrow canals of Levees 59, 60 and 61.
4. All ditches and canals connecting with items 2 and 3.

5. All ditches and canals from which water can be extracted from Lake Istokpoga.
6. The water table aquifers having substantial hydraulic connection with the elements of the surface water system enumerated in items 1, 2, 3, 4 and 5.

Water shortage measures, when found necessary, will be applied to the above-described elements as if they were a single water body.

The first 5 items are all surface water bodies and it is suggested permits issued for water withdrawals from all of these be given the designation "S." Item 6 is a goundwater source and it is suggested permits for extraction from that source be given the designation "G-1."

It is further suggested that all other water table aquifers in the designated geographical area be given the designation "G-2", and that the water body which has the generic name "Floridan Aquifer" (Artesian) be given the designation "G-3."

No overall classification as to use has been made as yet by the District. However, it is not believed necessary to do this first; it is believed appropriate, wherever possible, to establish use classifications on a basin basis.

Considering the "source" factor of the classification system as being the practical equivalent of a geographical description for purposes of a water shortage declaration, "use" becomes the only factor of the classification system (in the case of the study area of this report) which bears on the manner in which use restrictions are to be applied. For example, under present conditions of water use in this area, if there is a deficiency of stored water in Lake Istokpoga a water shortage would be declared for the area with restrictions to be applied only to those permits designated "S" and "G-1." The "G-2" and "G-3" permits would not be affected. The nature of

the restrictions in the area defined by geography and source, would be dependent only on use.

It is believed that a pragmatic approach must be taken in establishing use classifications for the Lake Istokpoga - Indian-Prairie Area and in developing the use restriction formulae to be applied in the event of a water shortage declaration. Such an approach takes cognizance of existing water uses within the area and probable water uses in the immediately foreseeable future. In addition, the District's immediate concern is with respect to the single source having the source designations "S" and "G-1." Consequently, use classification (and restriction formulae) should at this time be primarily oriented toward consideration of that source, and present and foreseeable future uses of that source.

On this basis water use for power production and for major mining and industrial enterprises can be eliminated from consideration. The large supplies of water needed to meet the requirements for such uses are not available and the District would not consider issuing allocation permits for such quantities of water. Smaller-size mining or industrial operations (shell-pits, concrete batch plants, etc.) should, however, be considered.

Public recreational use has already been considered in the establishment of minimum levels for Lake Istokpoga. Therefore, it can also be eliminated from consideration in establishing use classifications.

Remaining to be considered, then, of the use types enumerated in Chapter 16 CA-2.12 (2) (b) of the Rules and Regulations, are:

1. Domestic
2. Essential Service
3. Public Supply
4. Livestock
5. Agricultural
6. Industrial (minor)
7. Mining (minor)

Items 1 and 2 carry equal weight, as do items 4 and 5*, and items 6 and 7. A general ordering of priority would then be:

1. Domestic and Essential Services
2. Public Supply
3. Livestock and Agricultural
4. Industrial and Mining

* There is some merit in the view that stock-watering is a superior use in comparison with irrigation. For present purposes, however, the assumption of equivalency is adequate.

Public supply use is essentially a mixture of uses. It includes uses which are "domestic" and "essential services" (drinking, cooking, sanitation, fire-fighting, etc.). But it also includes uses which are the equivalent of "agricultural" (lawn sprinkling) and even the lower priority use "recreational" (filling swimming pools, car-washing, etc.). For this reason it is given a priority ranking between priority 1 and priority 3. This mixture of uses under the broad term "Public Supply" plays a part in the development and application of use restriction criteria.

If an appropriate water supply/demand accounting procedure is established, as recommended herein, the advent of a potential water shortage condition will be tracked. In addition, it is most likely that such conditions will occcur for only comparatively short periods of time (April, May). For these reasons (i.e.,timely action by the District, and short duration shortages) there should be no reason for having to restrict priority 1 uses.

Concerning public water supplies, information which we have unofficially obtained from reliable sources over the past several years indicates that lawn irrigation can account for anywhere between 25% and 65% of the finished

water production of municipal suppliers. When the application of restrictions becomes necessary, this share of public water supply allocation should be treated the same as the priority 3 uses. It is recommended that this share be established at 25%, with a maximum of 35%. (see following presentation).

Finally, to reflect the somewhat lower priority for mining and industrial uses (priority 4) it is suggested that, arbitrarily, the percentage restriction applied to users (permittees) in this classification be 5 percentage points greater than the percentage applied to priority 3 users.

In developing a water use restriction procedure it is recommended that the primary basis be the assessment or forecast of monthly supplies and demands. The capability should be developed, however, to make assessments on a shorter time interval. The recommended procedure is described below.

1. If the forecast shortage for the month is 25% or less than the estimated (or permitted) monthly demand:

In this case the priority 2 and priority 3 use restrictions are the same.

Let D = estimated deficiency for month

Q = total monthly demand

$= Q_1 + Q_2 + Q_3 + Q_4$

X = percent reduction to be applied to priority 2 uses

where Q_1 = total demand for priority 1 uses

Q_2 = total demand for priority 2 uses

Q_3 = total demand for priority 3 uses

Q_4 = total demand for priority 4 uses

since priority 1 uses are not restricted, the Q_1 term is eliminated. Then:

$100D = X(Q_2+Q_3) + (X+5(Q_4) = X(Q_2+Q_3+Q_4) + 5Q_4$

Example: D = 20,000 A.F.; Q = 110,000 A.F.; Q_1 = 10,000 A.F.

Q_2= 20,000 A.F.; Q_3= 70,000 A.F.; Q_4 = 10,000 A.F.

$2 \times 10^6 = 100{,}000X + 50{,}000$

$X = 19.5\%$

And restriction percentages would be:

Priority 1 permits - 0%

Priority 2 permits - 19.5%

Priority 3 permits - 19.5%

Priority 4 permits - 24.5%

2. If the forecast shortage for the month is between 25% and 35% of the estimated monthly demand:

In this case, the formula for case 1 is to be applied to the first 25% of the total estimated monthly demand and a remaining shortage volume determined. For the remainder of the shortage volume it is recommended that the priority 3 use restrictions be set at 5 percentage points higher than the priority 2 values.

For this remainder the formula would be:

$100D^1 = X \cdot Q_2^1 + (X+5)Q_3^1 + (X+10)Q_4^1$

$= X(Q_2^1+Q_3^1+Q_4^1) + 5Q_3^1 + 10Q_4^1$

Where D^1, Q_2^1, etc., are the remaining shortage and demand values.

Example:

D = 38,000 A.F.; all other values same as in previous example.

25% · 110,000 A.F. = 27,500 A.F.

$2{\cdot}75 \times 10^6 = 100{,}000X + 50{,}000$

$X = 27\%$

RECOMMENDATIONS

The following recommendations are made:

1. That the District adopt and publish by the appropriate and necessary means the values for:
   (a) Maintenance of minimum flows to Lake Okeechobee (see page 7 and Table 2)
   (b) Maintenance of minimum flows in Arbuckle Creek (see Table 11)
   (c) Maintenance of minimum flows in Josephine Creek (see Table 12)
   (d) Minimum monthly stages in Lake Istokpoga (see page 32 and Figure 4)
2. That the Department of Field Services establish minimum stages for each controlled reach of Canals 40, 41, 41A and 39A, and that these be adopted and published by the District by the appropriate and necessary means. (see page 27).
3. That new surface water allocations in the basin be made using the values presented in Table 14 as guidelines for technical evaluation.
4. That serious consideration be given to applying the allocation criteria of Table 14, based on hydrologic constraints, to existing permits to be converted; the final decision here to be made by the Executive Director upon the recommendation of the Regulation Division.
5. That all permittees, both old and new, be placed constructively on notice concerning the impact on water supply of the establishment of minimum monthly stages for Lake Istokpoga; preferably as a special condition of the permit.

6. That the potential for conjunctive use of groundwater from the water table aquifers and surface water be taken into account in considering applications for shallow groundwater use in the basin south of Lake Istokpoga. (see page 25).

7. That the Department of Field Services adopt the following order of operational priorities when circumstances exist such as to make choices necessary: (see pages 23 and 24).

   Priority 1: Maintenance of minimum canal stages.

   Priority 2: Maintenance of minimum Lake Istokpoga stages.

   Priority 3: Maintenance of flows to Lake Okeechobee.

8. That in issuing permits for impoundments in the basin such permits stipulate that impoundment of surplus surface waters above the allocated monthly amounts will not be allowed unless concurrent regulatory discharges from Lake Okeechobee are being made. (see page 19).

9. That the Regulation Division develop and maintain a supply-demand accounting procedure for the purpose of providing notice to permittees of an impending or existing water shortage in the area. (see page 27 and Figure 7).

10. That a permit classification system and water shortage plan for the Lake Istokpoga - Indian Prairie Area be established. (see page 28).

11. That all permittees, both old and new, be required to submit monthly reports of water usage in a form satisfactory to the District.

12. That the Resource Planning Department define the locations and characteristics of the shallow aquifer systems in the basin south of Lake Istokpoga to the extent necessary to reasonably

establish the hydraulic relationships between the aquifers and the surface water system.

13. That all permits, both old and new, be re-evaluated as a unit at the same time, and no later than mid-1977.

ISTOKPOGA - INDIAN PRAIRIE BASIN YIELD IN ACRE-FEET

YEAR	JAN.	FEB.	MARCH	APRIL	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.
1964	9,766	13,902	5,652	818	2,810	5,439	2,890	29,254	42,990	7,464	1,765	3,107
1965	661	1,614	3,633	1,826	912	7,624	5,754	6,183	8,757	36,515	21,108	2,145
1966	15,648	19,815	9,113	9,375	4,174	37,212	83,260	71,087	40,978	30,704	3,106	1,251
1967	675	1,695	3,768	818	912	10,408	21,575	13,925	18,521	19,452	2,291	1,251
1968	650	1,285	1,874	818	1,260	80,601	60,429	7,792	17,720	26,691	13,329	1,746
1969	3,621	1,661	31,040	990	8,830	23,536	6,999	71,550	25,391	111,334	36,321	24,533
1970	56,623	11,080	106,663	17,081	867	3,729	13,838	5,106	1,431	4,619	4,751	191
1971	141	143	127	137	117	9,461	17,050	42,499	114,080	37,866	9,596	218
1972	133	6,981	693	5,318	6,398	42,446	5,817	3,956	4,455	10,630	1,644	266
1973	1,278	3,949	5,379	2,469	1,530	9,141	51,085	35,420	83,629	23,569	1,395	1,356
AVG.	8,920	6,212	16,794	3,965	2,781	22,959	26,869	28,677	35,795	30,884	9,530	3,606

TABLE 1

BASIN YIELD

MONTH	TOTAL BASIN YIELD	FLOW MAINTENANCE REQUIREMENT	ADJUSTED BASIN YIELD (ALLOCABLE VOLUME)
JAN.	1,500	220	1,280
FEB.	3,000	650	2,350
MAR.	4,000	800	3,200
APR.	1,800	540	1,260
MAY	1,500	440	1,060
JUNE	15,000	6,500	8,500
JULY	15,000	5,800	9,200
AUG.	18,000	5,500	12,500
SEPT.	20,000	6,100	13,900
OCT.	21,000	9,200	11,800
NOV.	4,700	1,600	3,100
DEC.	1,100	360	740
TOTAL	All values in acre-feet		

TABLE 2

LAKE ISTOKPOGA DRY SEASON STAGE

MONTH	AVERAGE PAN EVAPORATION	ACTUAL EVAPORATION(a)	AVERAGE PRECIPITATION	AVERAGE EVAPORATION MINUS AVERAGE PRECIPITATION	PERCENTAGE	PERCENTAGE X (39.5-37.0)FT.	MINIMUM MONTHLY STAGE
NOV.	4.64	3.62	1.31	2.31	14.2	0.35	39.15
DEC.	3.59	2.80	1.20	1.60	9.8	0.24	38.91
JAN.	3.67	2.86	1.76	1.10	6.7	0.16	38.75
FEB.	4.25	3.32	2.25	1.07	6.5	0.16	38.59
MAR.	6.15	4.80	2.73	2.07	12.7	0.32	38.27
APR.	7.87	6.14	1.06	5.08	31.3	0.78	27.49
MAY	7.96	6.21	3.22	2.99	18.4	0.46	27.0
TOTAL	38.13	29.75	13.53	16.22			

(a) Evaporation Pan reading X 0.78 coefficient

TABLE 3

LAKE ISTOKPOGA MONTHLY DISCHARGE IN ACRE-FEET

YEAR	JAN.	FEB.	MARCH	APRIL	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.
1964	25,800	26,386	11,643	11,131	40,686	18,515	2,401	12,355	51,101	18,296	1,409	2,209
1965	10,502	4,689	8,083	8,083	11,282	1,113	33,374	46,531	27,733	25,975	15,330	8,929
1966	23,606	37,462	23,137	23,137	25,071	5,498	2,713	83,659	66,400	38,977	5,932	5,836
1967	4,384	2,160	15,788	15,788	11,400	1,600	304	385	1,919	30,220	5,947	5,089
1968	4,597	6,091	9,176	9,176	6,151	96,899	82,103	18,015	18,043	11,079	25,880	4,353
1969	13,875	7,141	32,185	32,185	26,455	57,370	21,391	50,445	57,639	121,436	44,637	42,897
1970	37,013	25,647	30,534	30,534	20,455	6,528	21,185	14,049	12,731	2,640	8,777	12,123
1971	10,885	9,514	15,635	12,448	5,603	5,437	648	2,561	7,131	12,744	11,219	6,408
1972	8,140	18,400	9,122	28,007	31,139	28,801	17,859	6,241	12,052	8,141	5,069	4,470
1973	5,218	3,381	46,696	29,838	24,595	7,602	16,145	44,131	81,105	24,614	8,255	7,058

Discharges are the sum of S-68 and Istokpoga Canal discharge and estimated irrigation withdrawals directly from Lake Istokpoga.

TABLE 4

LAKE ISTOKPOGA ACCUMULATED TOTAL DISCHARGE IN ACRE-FEET

YEAR	JUNE	JUNE JULY	JUNE JULY AUG.	JUNE JULY AUG. SEPT.	JUNE,JULY AUG.,SEPT. OCT.	NOV.	NOV. DEC.	NOV. DEC. JAN.	NOV. DEC. JAN. FEB.	NOV.,DEC. JAN.,FEB. MARCH	NOV.,DEC. JAN.,FEB. MAR.,APR.	NOV.,DEC. JAN.,FEB. MAR.,APR. MAY
1964-1965	18515	20916	33271	84372	102668	1409	3618	14120	18809	44196	52279	63561
1965-1966	1113	34487	81018	108751	134678	15330	24259	47865	85327	149674	172811	197882
1966-1967	5498	8211	91870	158270	197247	5932	11768	16152	18312	32877	48665	60065
1967-1968	1600	1904	2289	4208	34428	5947	11036	15633	21724	27846	37022	43173
1968-1969	96899	179002	197017	215060	226139	25880	30333	44108	51249	118348	150533	176988
1969-1970	57370	78761	129206	186845	308281	44637	87534	124547	150194	207471	238005	258460
1970-1971	6528	27713	41762	54493	57133	8777	20900	31785	41299	56934	69382	74985
1971-1972	5437	6085	8646	15780	28524	11219	17627	25767	44167	53289	81296	112435
1972-1973	28801	46660	52901	64953	73094	5069	9539	14757	18138	64834	94672	119267
1973	7602	23747	67878	148983	173597	8255	15313					

Accumulated Seasonal Monthly Discharges from Lake Istokpoga

TABLE 5

LAKE ISTOKPOGA MONTH-END STAGE

YEAR	JAN.	FEB.	MARCH	APRIL	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.
1964	38.93	38.92	38.68	38.47	37.54	37.18	37.47	38.46	38.86	39.09	39.04	39.05
1965	38.74	38.83	38.79	38.41	37.87	38.51	38.50	38.60	38.75	39.49	39.48	39.51
1966	39.40	39.46	38.76	38.23	37.73	37.56	38.59	38.73	38.99	39.34	39.26	39.15
1967	39.06	39.24	38.64	37.74	36.85	36.93	37.12	38.20	39.46	39.34	39.17	39.23
1968	39.20	39.04	38.68	38.00	37.86	38.22	38.03	38.57	38.87	39.48	39.45	39.47
1969	39.32	39.20	39.11	38.32	37.62	37.94	38.12	38.45	39.55	39.55	39.56	39.60
1970	39.70	39.49	39.03	38.31	37.62	37.76	38.29	38.47	38.77	39.09	38.74	38.39
1971	38.03	38.17	37.77	36.98	36.40	36.63	36.58	36.84	38.54	39.57	39.40	39.40
1972	39.35	39.35	39.12	38.19	37.51	37.97	37.97	38.54	38.35	37.90	37.96	38.00
1973	38.72	39.27	38.65	38.15	37.64	38.07	38.44	38.64	39.22	39.39	39.38	39.31

TABLE 6

LAKE ISTOKPOGA MONTH-END FICTITIOUS STAGES

YEAR	JAN.	FEB.	MARCH	APRIL	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.
1964						37.8	38.3	39.6	41.7	42.5	39.1	39.1
1965	39.2	39.5	40.3	40.2	40.0	38.5	39.7	41.3	42.3	43.8	40.0	40.3
1966	40.9	42.2	43.6	43.7	44.1	37.8	38.8	41.7	43.9	45.3	39.4	39.5
1967	39.6	39.8	39.7	39.8	38.9	37.0	37.1	38.3	39.6	40.4	39.3	39.5
1968	39.7	39.8	39.6	39.3	39.3	41.4	43.8	44.8	45.6	46.2	40.2	40.4
1969	40.7	40.7	42.9	43.2	43.4	39.9	40.7	42.8	45.2	48.3	41.1	42.4
1970	43.6	44.2	45.4	45.7	45.7	38.1	39.2	40.0	40.6	41.0	39.0	39.1
1971	39.1	39.6	39.8	39.5	39.1	36.8	36.9	37.0	39.0	40.6	39.7	39.9
1972	40.1	40.8	40.8	40.9	41.3	39.0	39.6	40.3	40.4	40.3	38.1	38.3
1973	39.2	39.8	40.8	41.2	41.7	38.3	39.2	40.8	43.9	44.7	39.6	39.7

TABLE 7

LAKE ISTOKPOGA CHANGE IN FICTITIOUS STAGE

YEAR	MAY 31 ACTUAL STAGE	JUNE	JULY	AUG.	SEPT.	OCT.
1964	37.5	.3	.8	2.1	4.2	5.0
1965	37.9	.6	1.8	3.4	4.4	5.9
1966	37.7	.1	1.1	4.0	6.2	7.6
1967	36.8	.2	.3	1.5	2.8	3.6
1968	37.9	3.5	5.9	6.9	7.7	8.3
1969	37.6	2.3	3.1	5.2	7.6	10.7
1970	37.6	.5	1.6	2.4	3.0	3.4
1971	36.4	.4	.5	.6	2.6	4.2
1972	37.5	1.5	2.1	2.8	2.9	2.8
1973	37.6	.7	1.6	3.2	6.3	7.1

TABLE 8

ARBUCKLE CREEK MONTHLY DISCHARGE IN ACRE-FEET

YEAR	JAN.	FEB.	MARCH	APRIL	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.
1940	14,502	16,986	20,832	18,388	6,401	11,048	30,625	28,726	53,830	27,738	8,318	7,803
1941	16,955	16,602	13,603	22,146	13,579	12,385	54,903	27,069	20,952	19,758	17,509	12,227
1942	18,804	15,921	27,108	14,282	8,722	23,140	23,730	16,303	16,549	13,985	5,061	4,861
1943	3,829	3,627	4,954	2,897	2,590	8,116	39,986	32,543	35,092	33,482	11,664	7,653
1944	6,075	4,449	3,726	6,797	6,215	4,154	11,559	34,014	17,600	17,107	11,300	6,918
1945	7,746	5,176	3,364	1,632	804	2,404	59,079	43,720	87,164	44,023	17,600	11,246
1946	9,900	5,871	5,203	3,437	2,772	4,059	8,872	17,701	27,623	25,033	12,846	8,126
1947	5,881	6,467	22,227	15,905	10,401	51,801	58,559	72,686	102,683	69,821	30,045	22,125
1948	20,556	18,721	10,534	11,270	8,960	6,574	14,250	62,392	109,395	104,471	30,579	20,067
1949	13,478	7,829	5,451	4,004	3,176	5,180	10,502	40,131	80,152	66,716	17,438	10,858
1950	7,823	5,019	3,766	2,188	1,956	2,612	5,106	4,261	7,005	27,639	16,234	9,443
1951	7,217	6,453	4,843	30,250	6,227	4,118	41,705	42,861	29,581	49,167	20,436	12,246
1952	8,300	11,009	13,820	11,514	6,213	5,578	9,993	17,291	15,721	62,384	38,335	14,593
1953	13,890	10,276	10,545	21,489	12,609	33,296	31,629	35,517	112,009	157,054	45,334	54,478
1954	29,128	16,559	13,492	14,395	12,851	53,072	34,345	25,716	36,505	30,237	13,824	11,179
1955	10,003	8,136	6,033	5,601	2,837	2,196	8,094	6,273	9,710	6,675	3,425	2,610
1956	2,424	2,061	1,372	556	598	1,919	2,829	6,562	12,830	50,914	14,757	6,849

TABLE 9a

YEAR	JAN.	FEB.	MARCH	APRIL	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.
1957	5,728	4,768	13,420	19,083	34,765	32,070	44,841	48,754	41,635	39,697	11,490	10,419
1958	31,088	26,461	33,416	28,563	15,747	11,985	19,707	14,410	16,291	8,930	4,071	6,524
1959	8,754	7,292	40,426	18,044	10,852	75,563	51,617	47,566	93,963	94,557	42,323	18,184
1960	14,098	22,020	32,030	33,870	14,288	16,012	30,506	94,939	145,239	81,863	29,417	14,900
1961	18,731	12,815	12,369	9,439	5,851	4,930	6,043	4,877	9,953	4,336	2,485	2,321
1962	2,635	1,786	1,911	2,649	1,018	11,486	30,850	43,806	45,904	23,966	15,101	6,946
1963	7,874	18,640	26,809	5,853	5,073	10,842	16,072	7,869	14,767	13,333	7,647	8,102
1964	15,404	18,523	10,797	6,722	8,441	7,451	6,931	15,503	37,741	16,721	6,205	5,835
1965	5,055	5,665	18,095	6,827	3,992	9,557	32,805	38,115	19,198	29,783	17,293	11,636
1966	13,638	30,751	36,285	13,088	10,019	20,659	26,696	62,913	44,324	25,199	8,142	5,374
1967	3,338	4,281	4,041	984	212	1,432	7,288	26,682	26,952	31,512	6,492	4,788
1968	3,994	3,067	2,782	1,370	4,247	49,308	75,686	24,449	10,472	22,604	19,774	7,708
1969	9,102	6,694	41,235	6,003	4,604	25,679	15,442	36,202	65,346	108,108	40,453	35,994
1970	32,023	14,185	26,092	16,056	4,934	4,598	10,357	9,832	10,454	10,536	4,075	3,780
1971	3,970	4,285	3,669	2,622	1,123	1,810	3,400	5,397	25,447	33,555	10,131	6,643
1972	5,853	11,955	4,726	3,592	6,863	18,473	20,099	9,348	5,485	3,457	2,705	6,447
1973	9,641	13,153	15,517	20,406	13,755	7,742	18,030	45,809	57,390			

TABLE 9b

JOSEPHINE CREEK MONTHLY DISCHARGE IN ACRE-FEET

YEAR	JAN.	FEB.	MARCH	APRIL	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	
1947	1,273	1,481	5,742	5,461	4,255	13,151	19,511	20,111	28,259	26,651	17,598	12,159	155,652
1948	10,252	9,013	5,548	4,803	3,600	2,263	7,520	22,647	37,293	34,765	13,915	9,664	161,285
1949	5,574	3,305	1,994	1,832	1,715	1,632	4,180	11,405	15,424	11,159	4,473	3,008	65,698
1950	2,186	1,374	849	360	356	404	618	545	2,618	2,607	2,156	1,348	15,521
1951	863	1,186	620	2,984	1,594	394	4,209	6,108	5,778	10,264	5,805	4,328	44,134
1952	3,025	3,128	3,578	2,721	2,340	2,629	3,330	6,231	7,821	7,975	5,997	3,570	52,401
1953	3,221	2,631	1,923	1,491	1,008	6,827	11,462	14,018	27,152	36,879	15,846	12,335	134,794
1954	7,750	4,663	3,972	3,089	1,903	6,574	10,470	13,163	15,452	9,555	5,160	4,558	86,308
1955	3,907	3,111	1,853	1,038	537	939	3,443	3,255	5,918	3,493	1,536	1,123	30,151
1956	861	628	305	113	65	186	192	647	1,800	6,201	2,657	1,239	14,878
1957	1,026	923	2,679	3,061	3,540	3,132	5,661	9,183	14,090	14,630	5,354	3,934	67,213
1958	7,789	7,678	10,862	10,512	8,059	5,239	6,958	8,573	6,538	3,188	1,990	1,558	78,945
1959	1,715	1,299	4,362	4,520	1,927	8,459	15,228	21,334	26,087	29,813	13,664	7,566	135,973
1960	5,005	6,886	9,130	9,920	4,813	7,092	16,691	37,671	45,730	28,651	10,153	3,994	185,738
1961	7,225	6,378	2,843	2,606	1,606	3,645	4,198	3,740	3,685	1,689	933	788	39,334
1962	640	370	347	354	194	2,439	8,082	6,120	9,579	9,045	3,437	3,219	43,827
1963	2,740	4,004	7,504	1,655	1,216	1,982	2,721	3,364	3,105	2,445	1,925	1,517	34,177
1964	2,128	3,599	2,421	948	1,013	704	1,188	2,880	8,383	3,785	1,118	619	28,793
1965	641	619	1,098	291	178	453	1,463	4,565	5,367	6,745	3,449	1,384	26,264
1966	2,102	5,977	5,296	2,229	1,233	5,304	8,781	11,054	19,697	12,586	2,977	1,724	78,966
1967	1,463	1,296	760	368	298	344	475	1,805	3,267	3,920	675	750	15,426
1968	615	409	465	283	251	10,195	8,017	5,724	4,229	3,783	3,217	1,578	38,772
1969	1,597	1,005	6,979	3,259	1,437	12,456	5,650	11,440	11,880	13,149	8,064	7,407	84,328
1970	10,068	5,755	11,466	8,264	1,354	2,651	9,900	6,298	3,601	3,403	1,338	916	65,019
1971	821	869	1,116	423	334	322	530	2,768	9,977	4,874	1,659	1,350	25,048
1972	1,102	1,879	966	1,199	833	2,617	3,154	4,813	3,716	1,063	932	1,756	24,035
1973	2,874	3,829	3,179	1,815	912	2,108	2,253	3,245	9,353				

TABLE 10

ARBUCKLE CREEK DISCHARGE DATA IN ACRE-FEET

MONTH	TWO YEAR FREQUENCY DISCHARGE	TRIBUTARY ALLOCATION	MINIMUM DISCHARGE TO LAKE ISTOKPOGA	MINIMUM MONTHLY FLOW RATE IN CFS
JANUARY	9,500	475	9,025	4,558
FEBRUARY	9,500	475	9,025	4,558
MARCH	9,500	475	9,025	4,558
APRIL	8,200	410	7,790	3,934
MAY	5,800	290	5,510	2,783
JUNE	9,000	450	8,550	4,318
JULY	20,000	1,000	19,000	9,596
AUGUST	28,000	1,400	26,600	13,430
SEPTEMBER	29,000	1,450	27,550	13,910
OCTOBER	30,000	1,500	28,500	14,390
NOVEMBER	12,000	600	11,400	5,758
DECEMBER	8,200	410	7,790	3,934

TABLE 11

JOSEPHINE CREEK DISCHARGE DATA IN ACRE-FEET

MONTH	TWO YEAR FREQUENCY DISCHARGE	TRIBUTARY ALLOCATION	MINIMUM DISCHARGE TO LAKE ISTOKPOGA	MINIMUM MONTHLY FLOW RATE IN CFS
JANUARY	2,100	105	1,995	1,008
FEBRUARY	2,100	105	1,995	1,008
MARCH	2,100	105	1,995	1,008
APRIL	1,700	85	1,615	816
MAY	1,100	55	1,045	528
JUNE	2,200	110	2,090	1,056
JULY	4,500	225	4,275	2,159
AUGUST	6,100	305	5,795	2,927
SEPTEMBER	8,500	425	8,075	4,078
OCTOBER	6,700	335	6,365	3,215
NOVEMBER	3,100	155	2,945	1,487
DECEMBER	2,400	120	2,280	1,152

TABLE 12

TOTAL IRRIGATION WITHDRAWALS FROM LAKE ISTOKPOGA IN ACRE-FEET

YEAR	JAN.	FEB.	MARCH	APRIL	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.
1964	789	194	4,982	10,187	12,581	8,737	1,851	342	2,673	14,546	89	303
1965	7,310	2,289	4,895	6,295	10,376	515	8,220	3,464	3,939	589	1,198	4,887
1966	3,992	2,203	2,867	9,096	9,779	2,625	270	0	0	22	3,476	3,917
1967	2,703	458	5,682	15,093	11,162	1,203	0	0	0	373	4,487	4,364
1968	3,197	5,396	5,662	8.693	5,812	469	1,865	733	1,492	0	1,539	3,284
1969	3,387	2,934	1,106	11,443	6,357	1,250	1,456	2,002	5,284	2,023	220	686
1970	114	3,011	498	3,834	15,502	858	3,834	2,731	4,862	0	3,600	11,149
1971	8,854	6,167	12,079	11,353	5,456	1,664	0	0	0	0	1,062	5,396
1972	6,362	5,361	5,453	6,809	10,392	925	1,628	3,504	2,254	1,672	1,456	3,453
1973	3,398	0	6,417	5,783	7,990	2,720	0	0	0	0	1,907	2,276
AVG.	4,011	2,801	4,964	8,859	9,541	2,097	1,913	1,096	2,050	1,922	1,903	3,971

AVERAGE DRY SEASON WITHDRAWALS - 36,050 ACRE-FEET

AVERAGE WET SEASON WITHDRAWALS - 9,078 ACRE-FEET

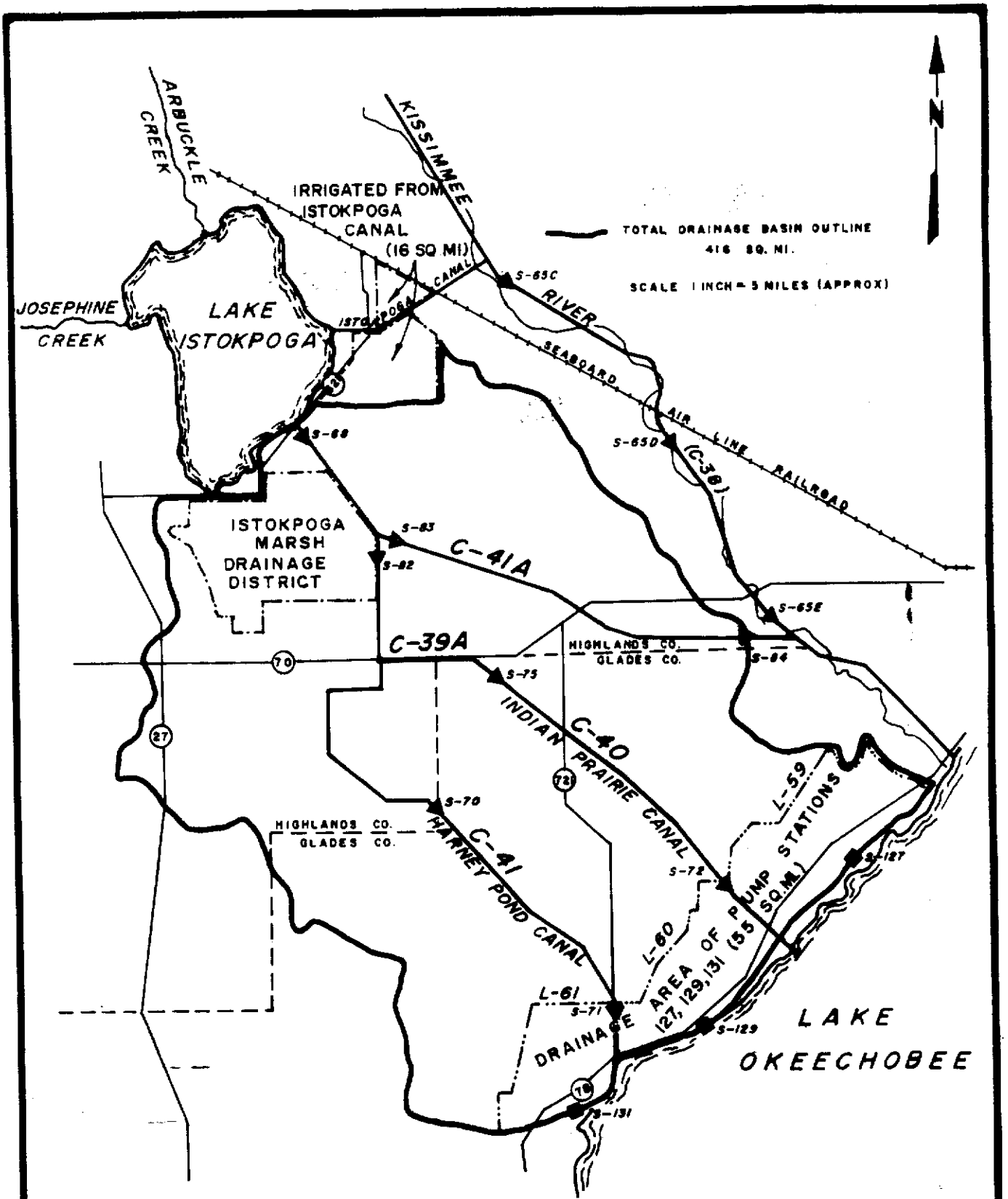
TABLE 13

MAXIMUM PERMISSIBLE ALLOCATIONS

	VOLUME - ACRE FEET			FROM LAKE		FROM CANALS	
PERIOD	BASIN YIELD	LAKE STORAGE	TOTAL	AS NEEDED "/A	IMPOUNDMENT "/A	AS NEEDED "/A	IMPOUNDMENT "/A
NOV.	3,100	15,900	19,000		0.8		0.9
DEC.	740	10,900	11,640		0.5		0.5
JAN.	1,280	7,900	9.180		0.4		0.4
FEB.	2,350	7,700	10,050		0.4		0.5
MARCH	3,200	14,300	17,500		0.7		0.8
APRIL	1,260	35,200	36,460		1.8		1.8
MAY	1,060	20,700	21,760		1.0		1.0
DRY SEASON	12,990	112,600	125,590	5.6		5.9	
JUNE	8,500	18,400	26,900		0.9		1.3
JULY	9,200	18,450	27,650		0.9		1.3
AUG.	12,500	18,450	30,950		0.9		1.4
SEPT.	13,900	18,450	32,350		0.9		1.5
OCT.	11,800	18,450	30,250		0.9		1.4
WET SEASON	55,900	92,200	148,100	4.5		6.9	
ANNUAL	68,890	204,800	273,690	10.1		12.8	

"/A = inches/acre

TABLE 14



DRAINAGE BASIN

LAKE ISTOKPOGA — INDIAN PRAIRIE AREA

CANAL C-40, C-41, C-41A

C-39A

FIGURE 1

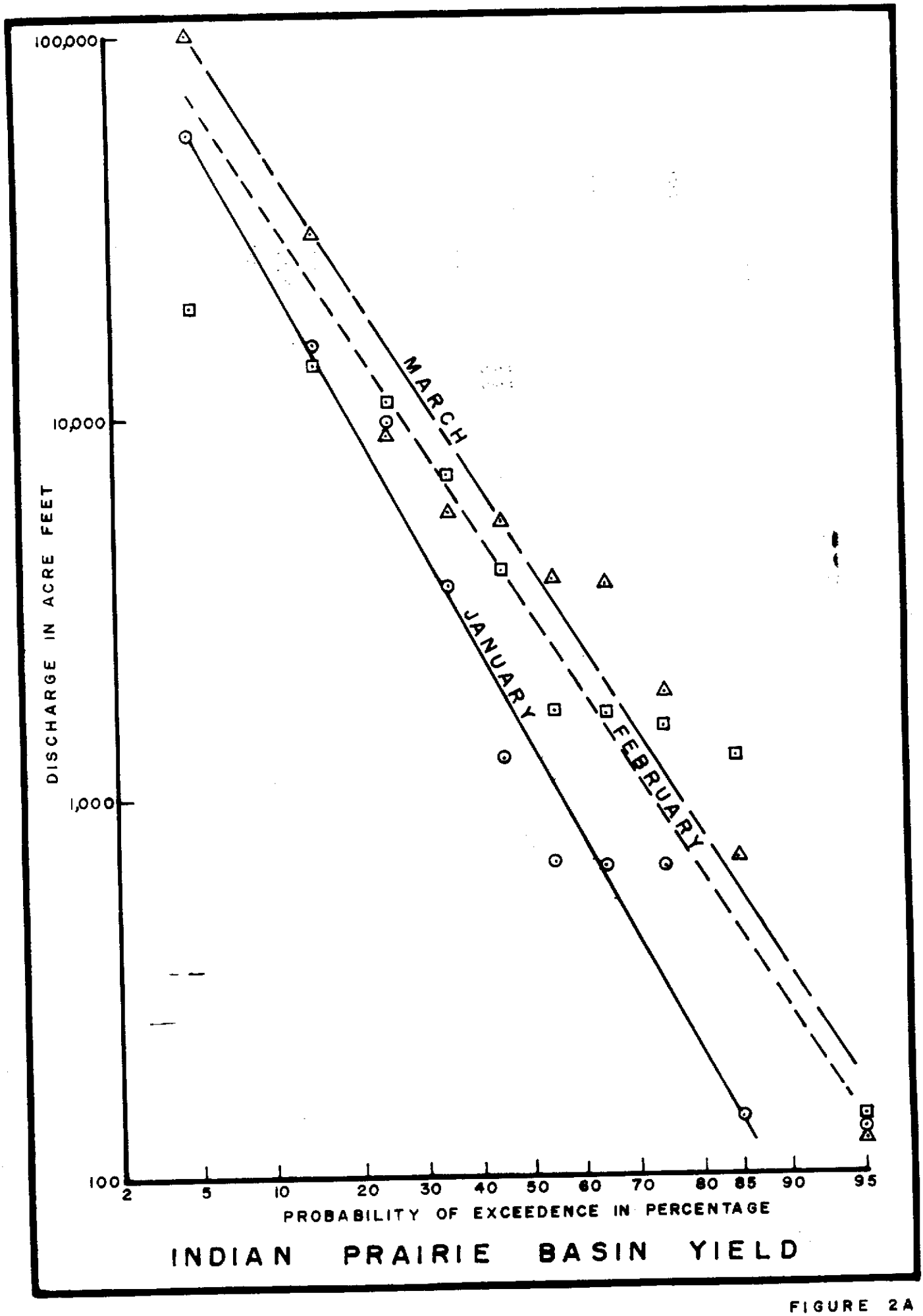
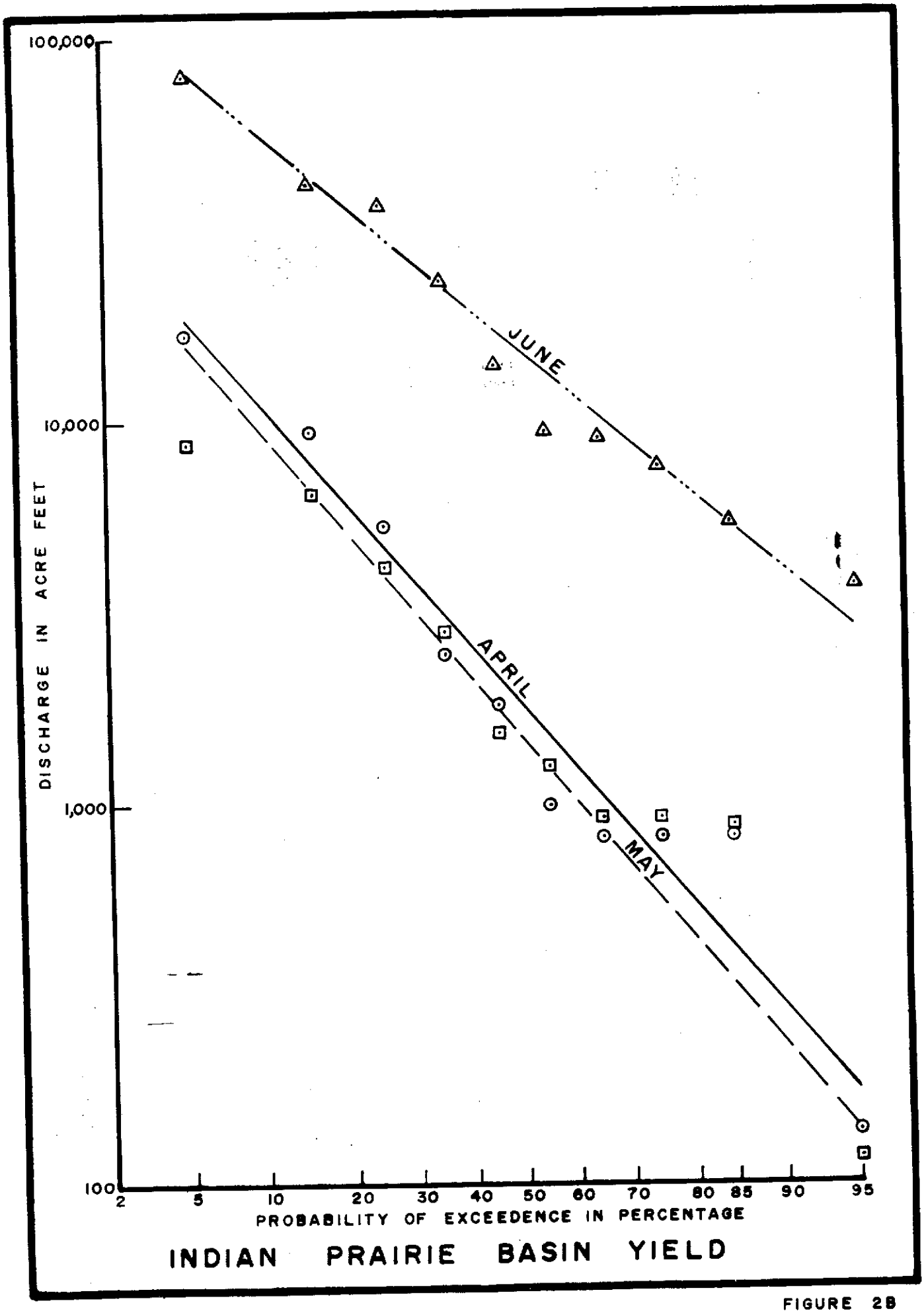
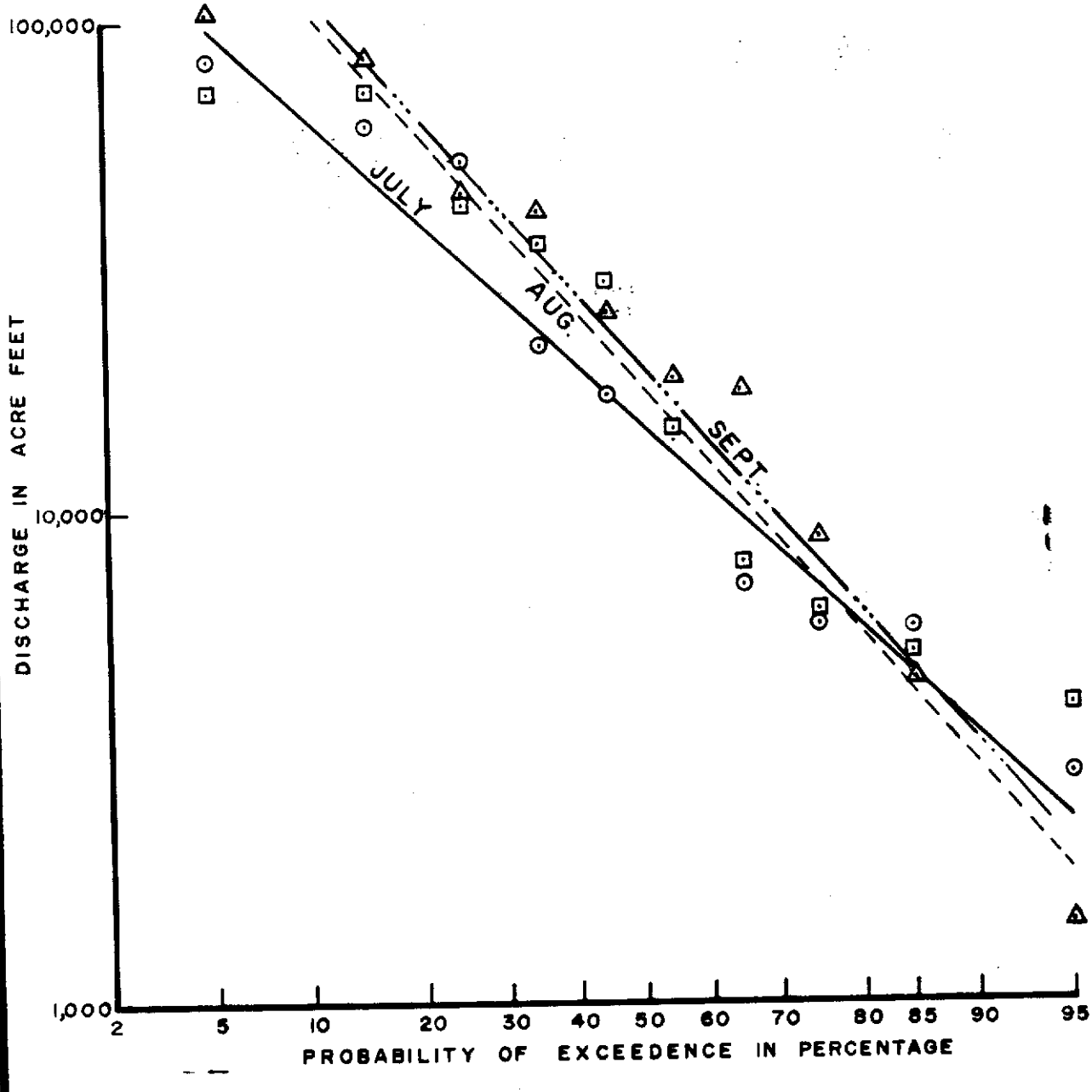

100,000
10,000
1,000
100
DISCHARGE IN ACRE FEET
MARCH
FEBRUARY
JANUARY
2
5
10
20
30
40
50
60
70
80
85
90
95
PROBABILITY OF EXCEEDENCE IN PERCENTAGE
INDIAN PRAIRIE BASIN YIELD

FIGURE 2A



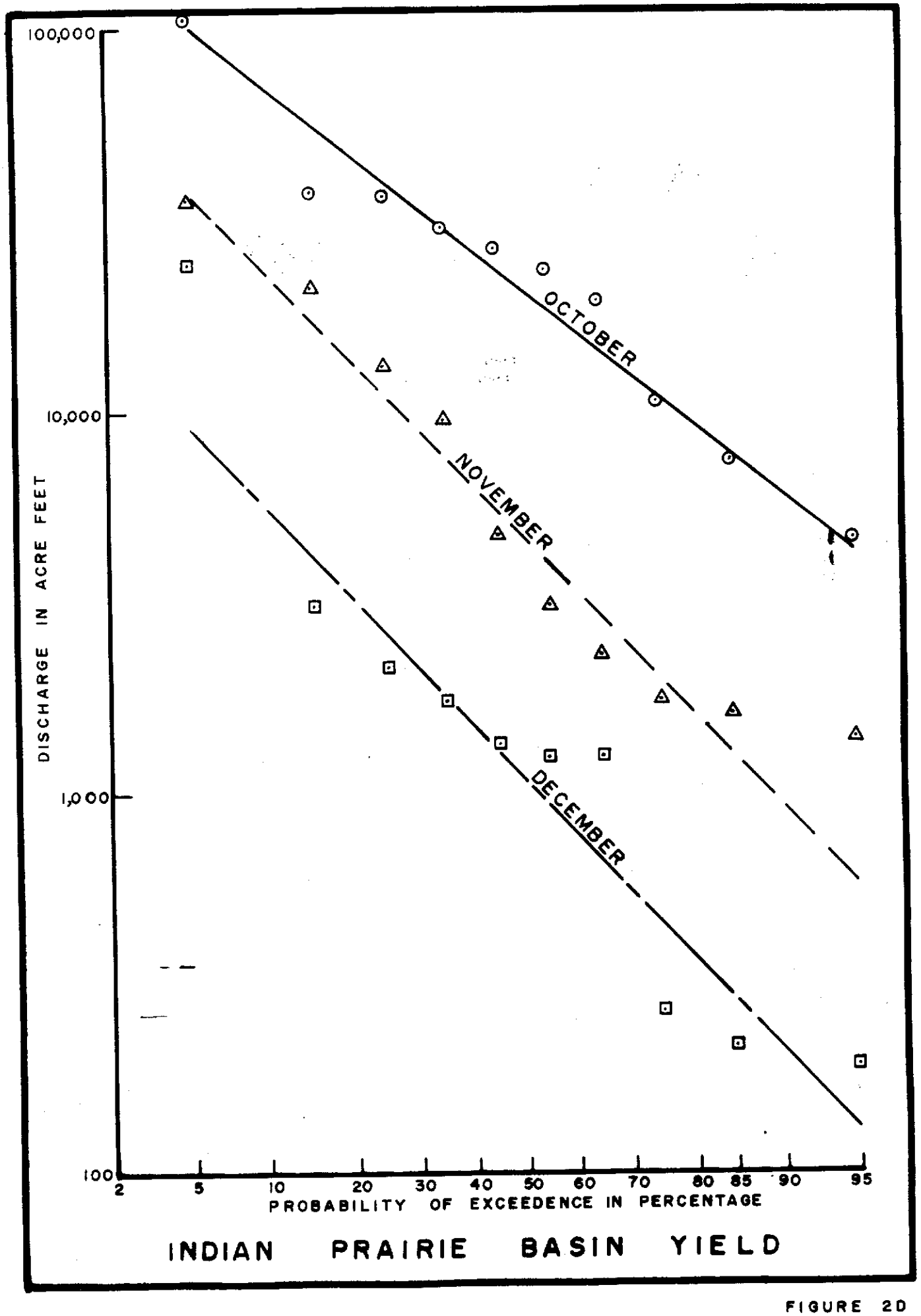
INDIAN PRAIRIE BASIN YIELD

FIGURE 28



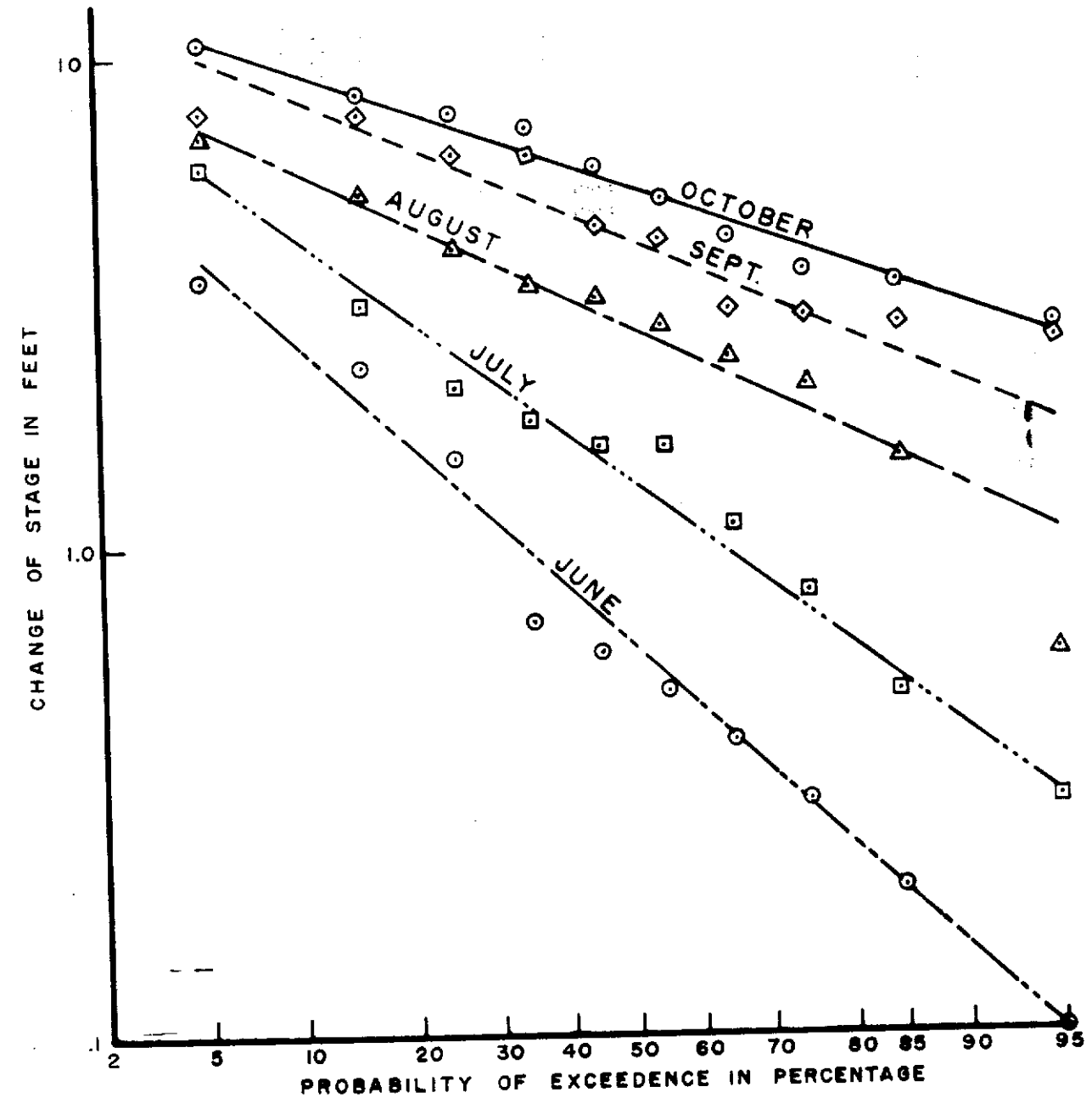
INDIAN PRAIRIE BASIN YIELD

FIGURE 2C



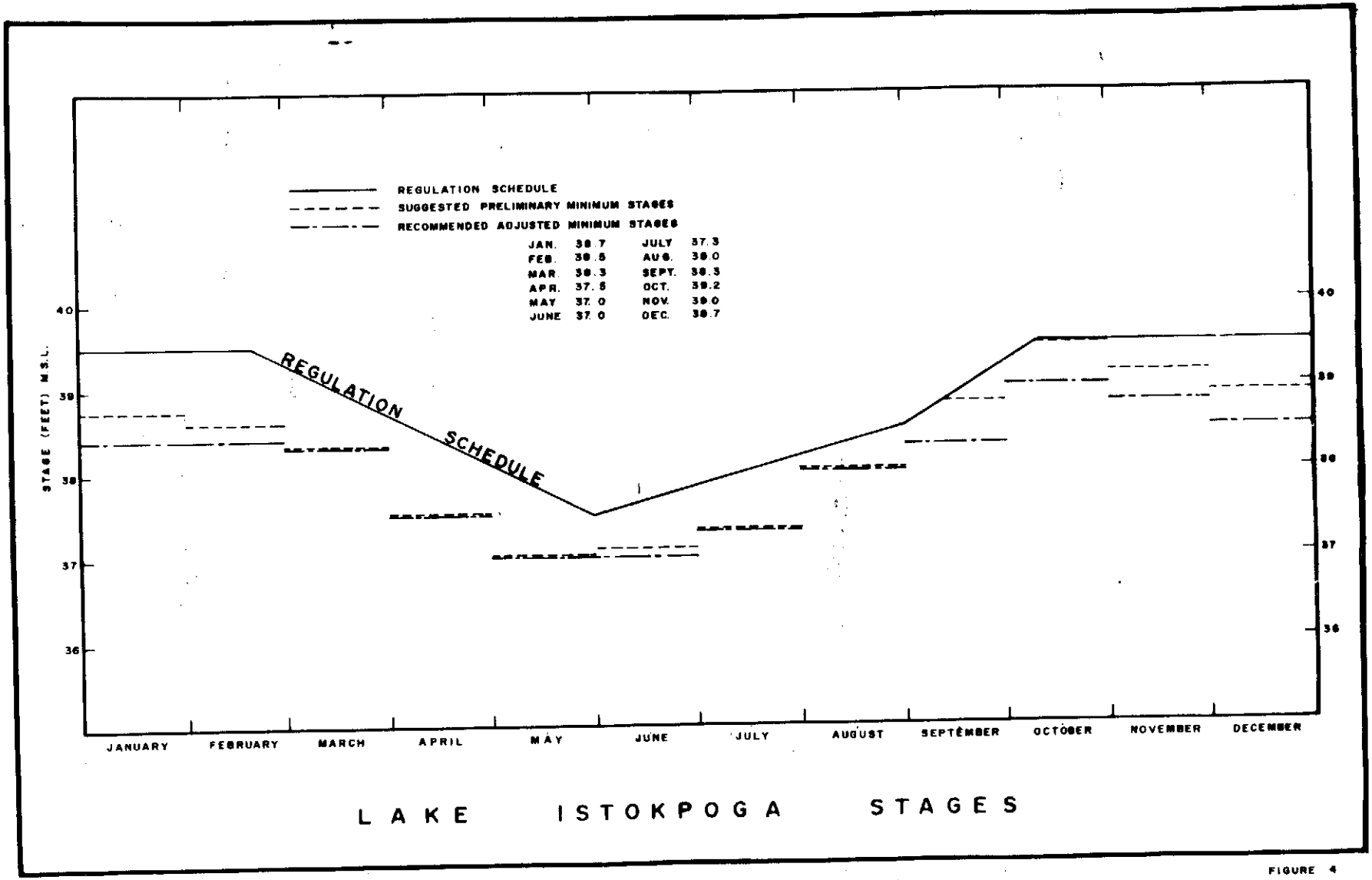
INDIAN PRAIRIE BASIN YIELD

FIGURE 2D



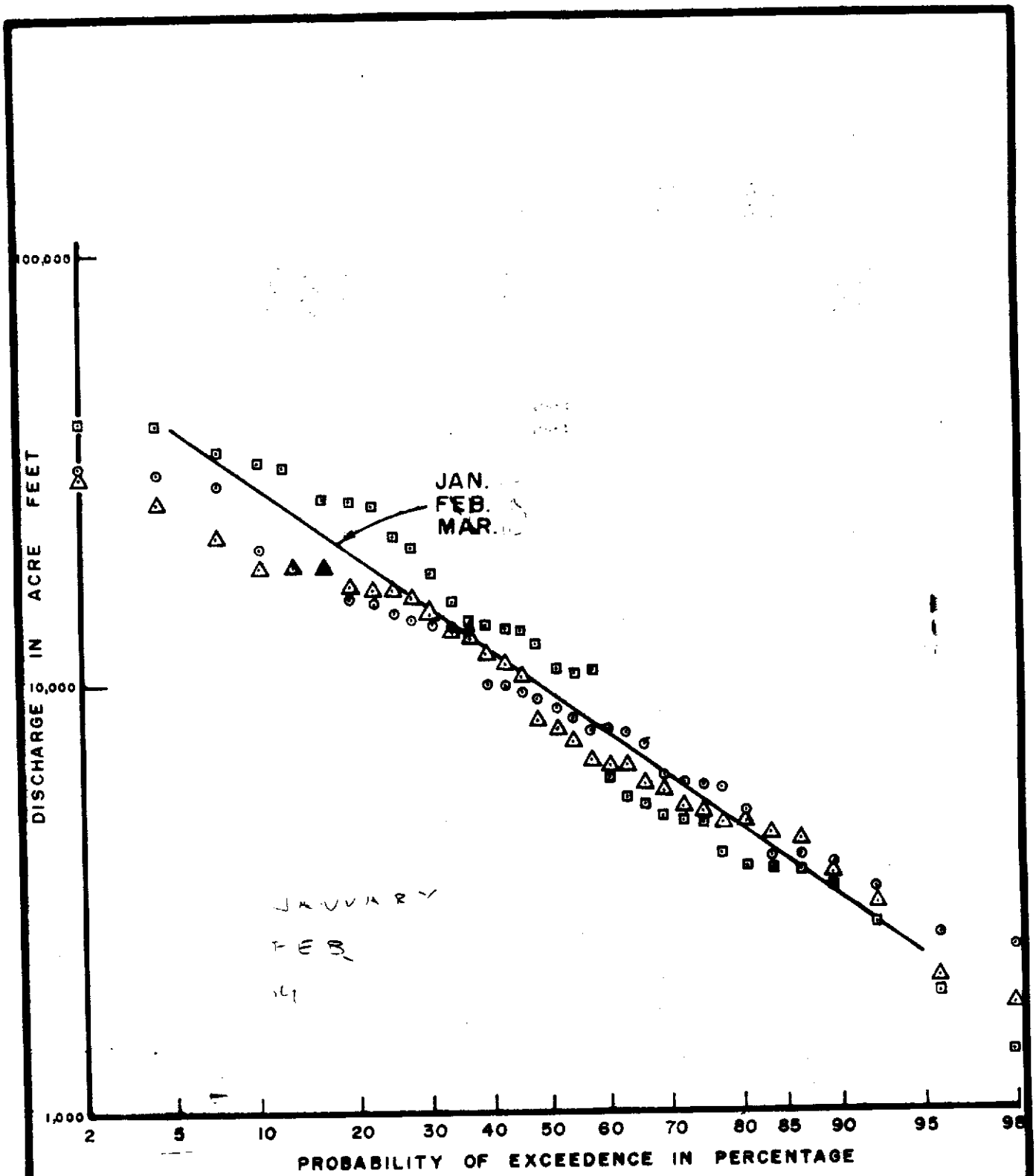
LAKE ISTOKPOGA CHANGE OF FICTITIOUS STAGE

FIGURE 3



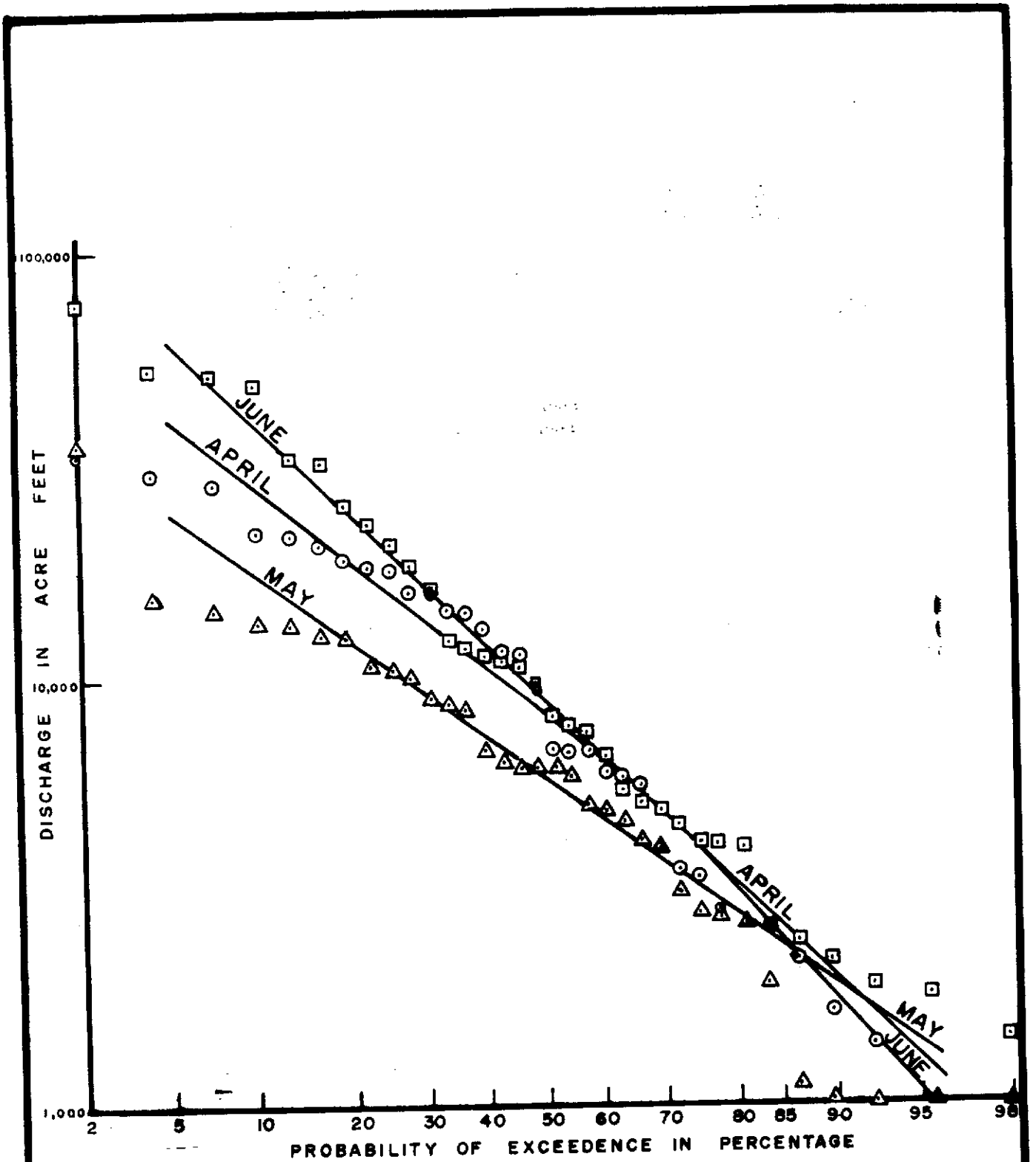
LAKE ISTOKPOGA STAGES

FIGURE 4



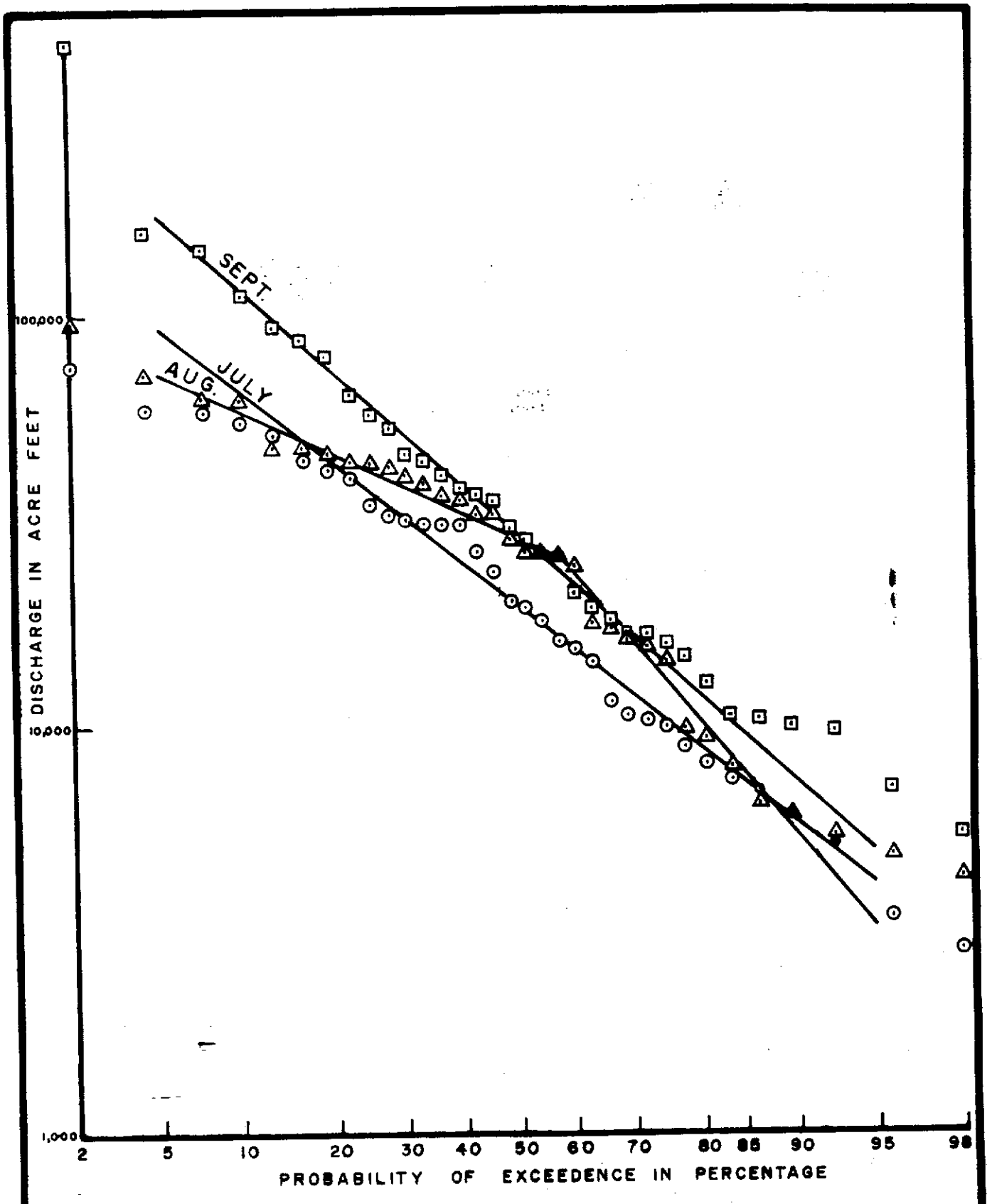
ARBUCKLE CREEK DISCHARGE — FREQUENCY CURVE

FIGURE 5A



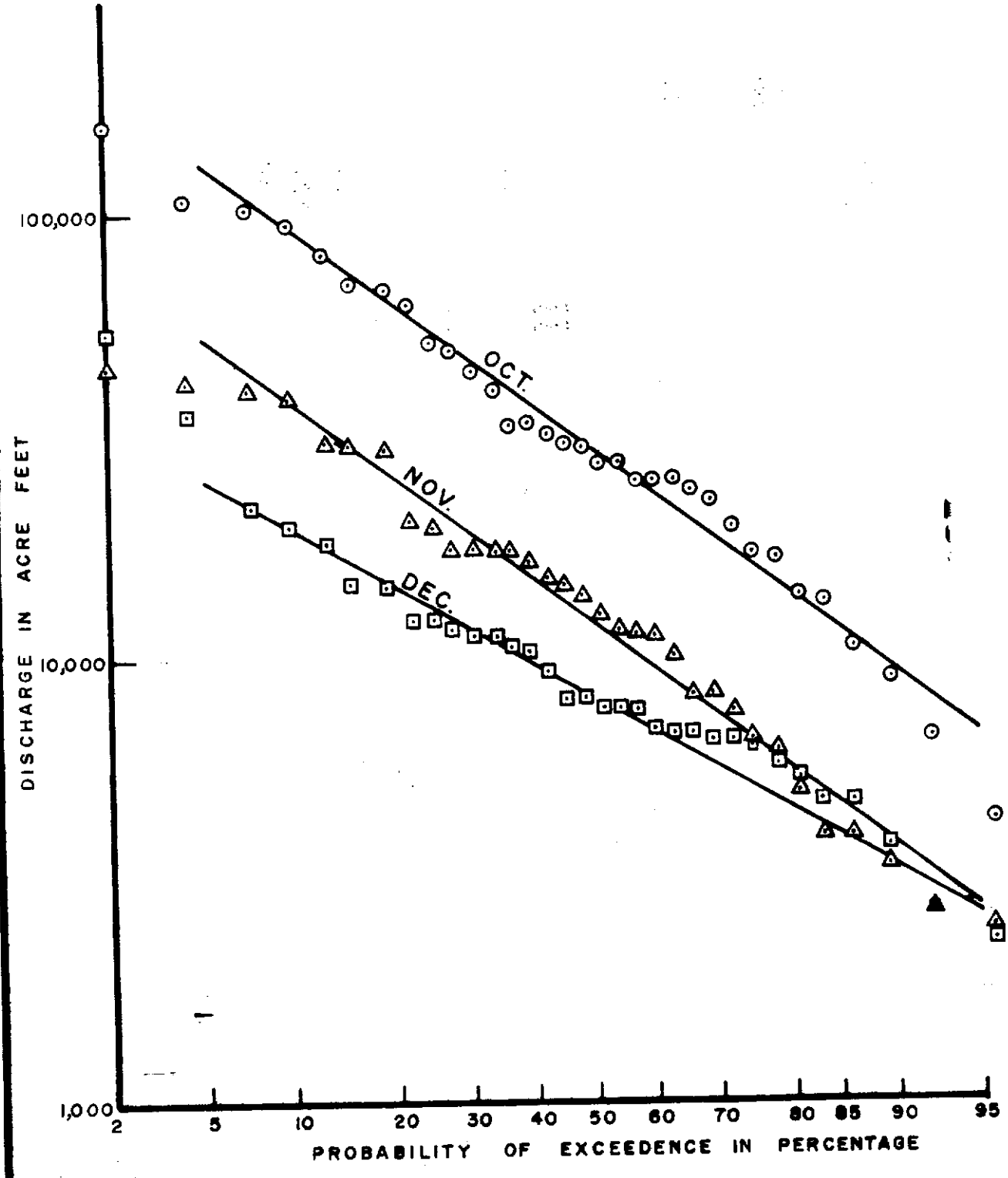
ARBUCKLE CREEK DISCHARGE—FREQUENCY CURVE

FIGURE 58



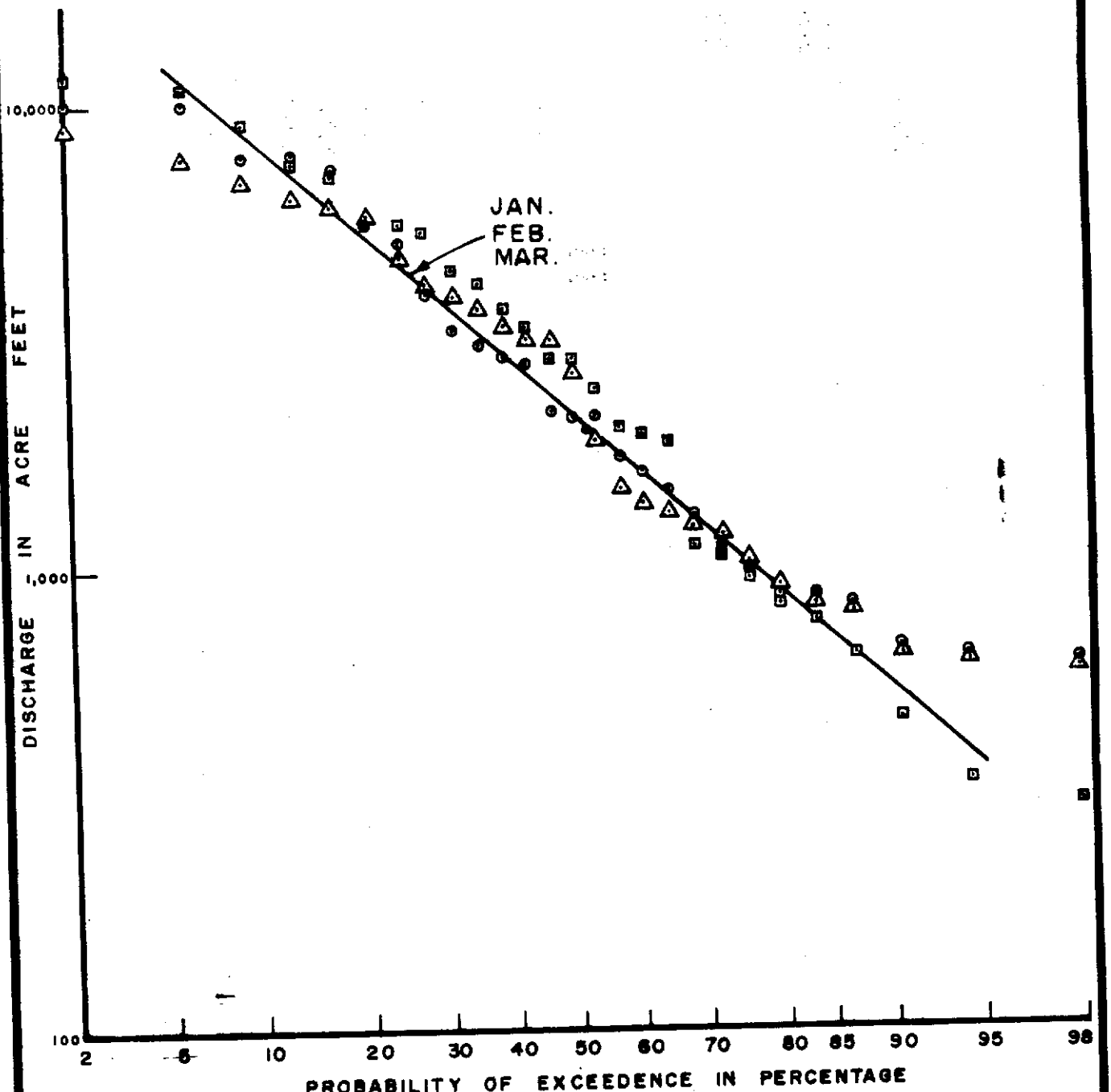
ARBUCKLE CREEK DISCHARGE—FREQUENCY CURVE

FIGURE 5C



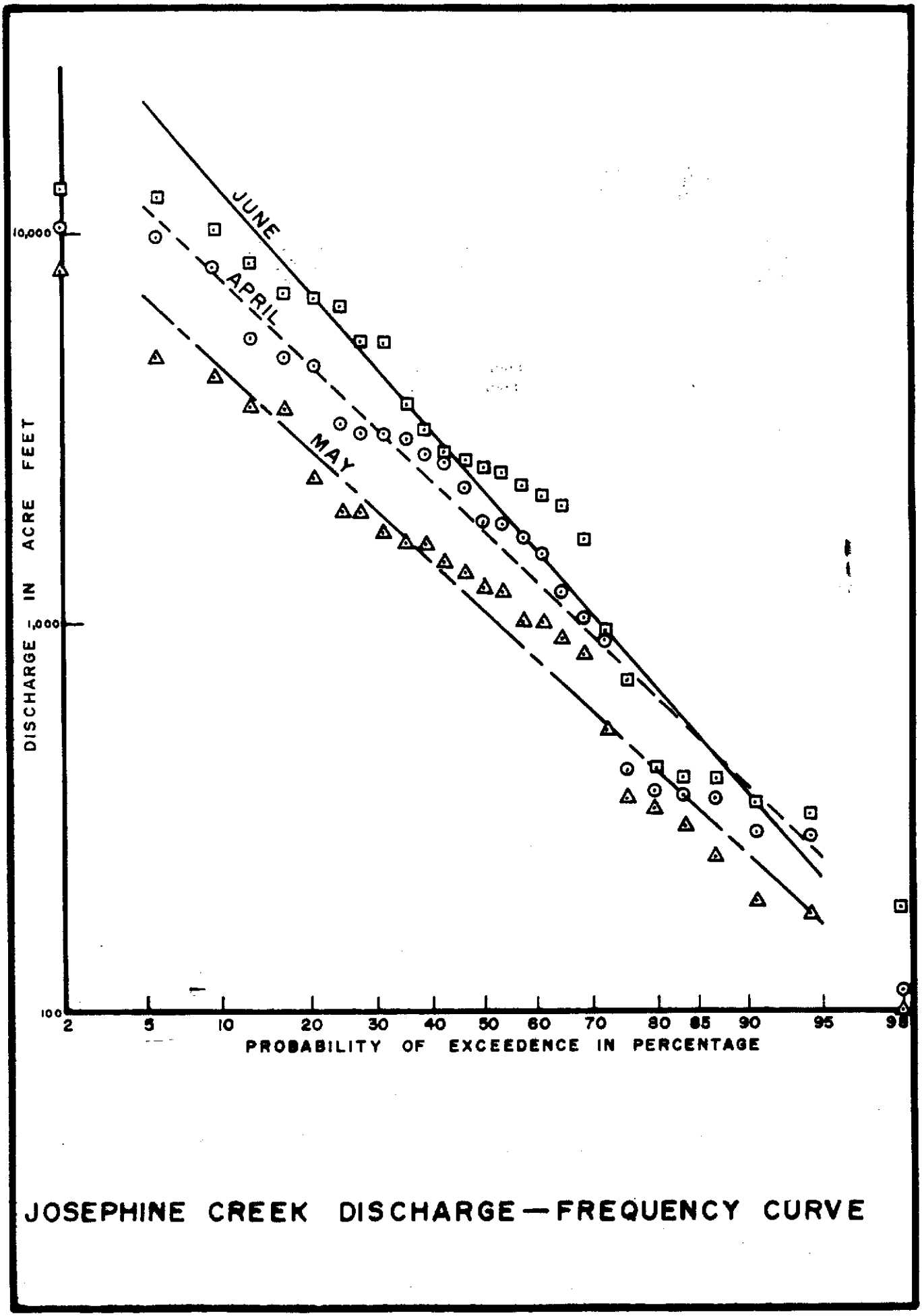
ARBUCKLE CREEK DISCHARGE—FREQUENCY CURVE

FIGURE 5D



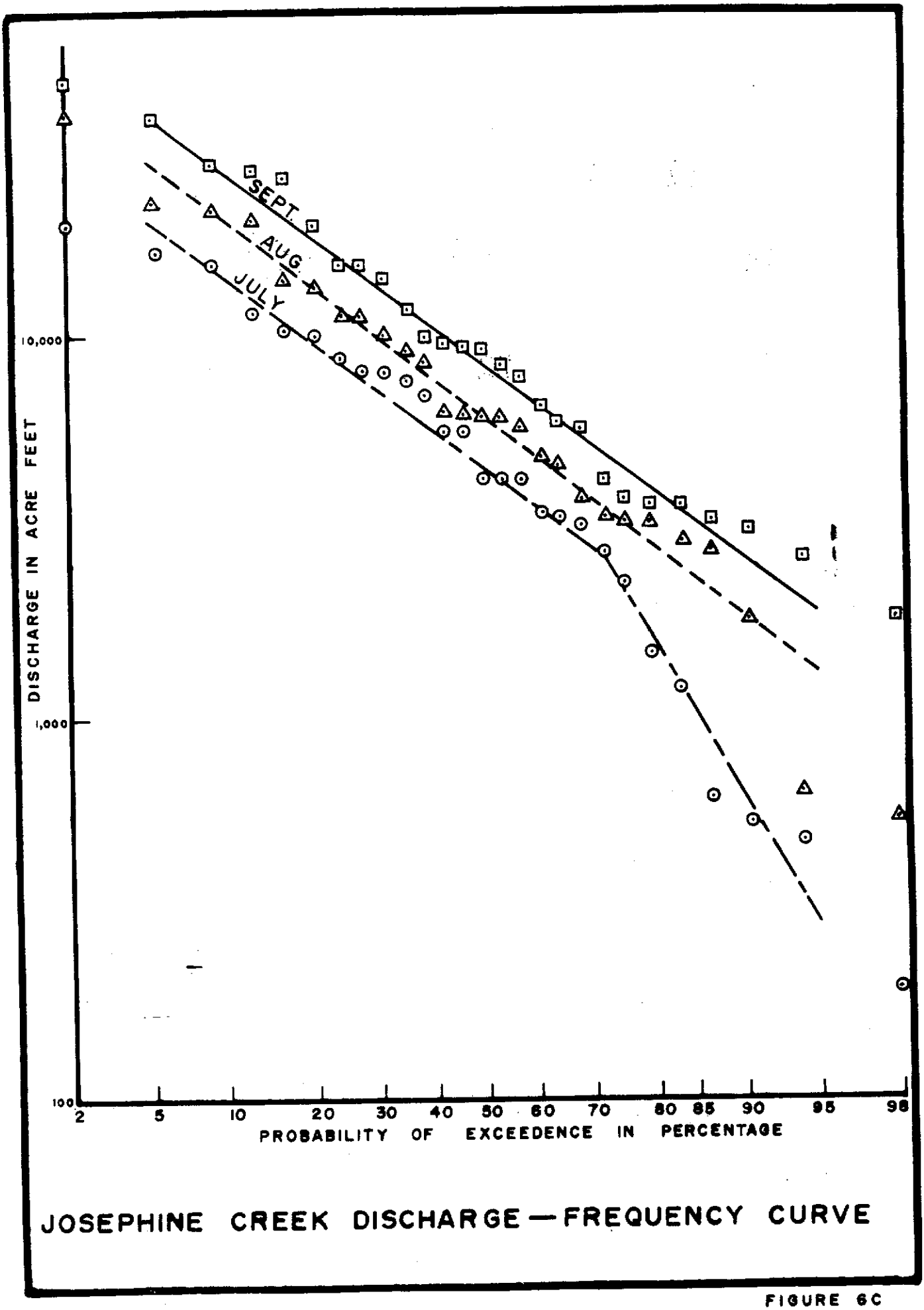
JOSEPHINE CREEK DISCHARGE— FREQUENCY CURVE

FIGURE 6A



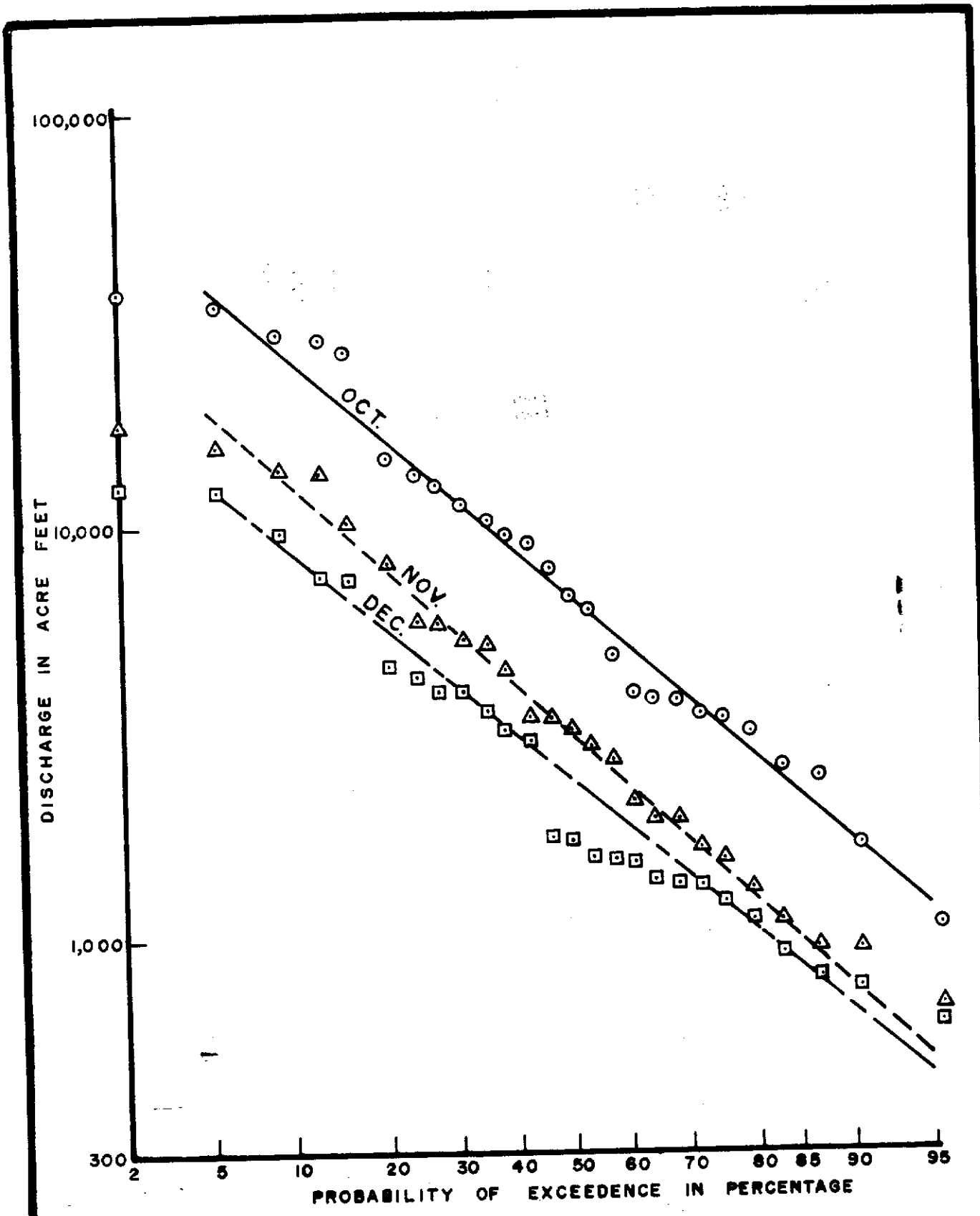
JOSEPHINE CREEK DISCHARGE—FREQUENCY CURVE

FIGURE 68



JOSEPHINE CREEK DISCHARGE — FREQUENCY CURVE

FIGURE 6C



JOSEPHINE CREEK DISCHARGE— FREQUENCY CURVE

FIGURE 60

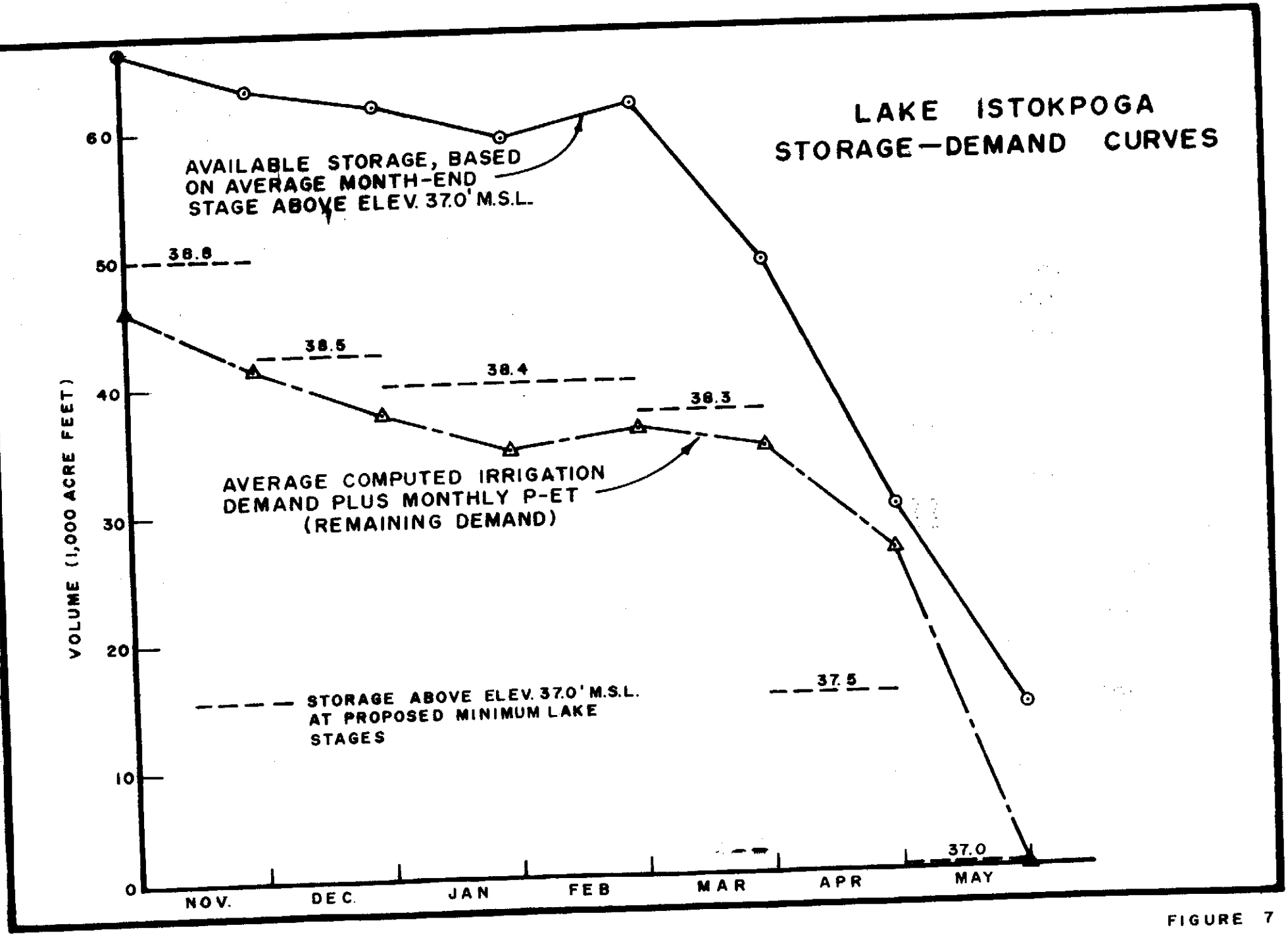

LAKE ISTOKPOGA
STORAGE—DEMAND CURVES
AVAILABLE STORAGE, BASED ON AVERAGE MONTH-END STAGE ABOVE ELEV. 37.0' M.S.L.
AVERAGE COMPUTED IRRIGATION DEMAND PLUS MONTHLY P-ET (REMAINING DEMAND)
STORAGE ABOVE ELEV. 37.0' M.S.L. AT PROPOSED MINIMUM LAKE STAGES
38.6
38.5
38.4
38.3
37.5
37.0
VOLUME (1,000 ACRE FEET)
0
10
20
30
40
50
60
NOV.
DEC.
JAN
FEB
MAR
APR
MAY

FIGURE 7